GALILEI LINCEO FILOSOFO E
MATEMATICO DEL SER^MO GRAN
DVCA DI TOSCANA GALILEO

ASTRONOMY AND WAR

From an interview with Dr. Roy K. Marshall, of The Franklin Institute Staff

THE most obvious relation between astronomy and military science lies, of course, in the specialized fields. Any professional astronomer could at once serve as a ballistics expert. Men who have worked in optics are invaluable at the present time. Theodore Dunham, for example, is designing Schmidt cameras for aerial photography, and for use in anti-aircraft explosion photography. These are the fields we should think of immediately, but there are many ways in which an amateur's knowledge of the stars, the sun and the moon can help.

The British government has asked anyone owning a planisphere to send it to headquarters for use by airplane watchers. A night-watcher, with his mouth to a telephone, looks for enemy planes. If he can report the constellation in which the plane appears, the position of the attacker can be determined at once, and anti-aircraft fire set up. Knowledge of the constellations is helpful, also, in field work, where directions are not always clear.

The moon plays an important part in military operations. It is important to know the motions of the moon, the times of rising and setting at each phase. Lawrence of Arabia, in the **Seven Pillars of Wisdom,** tells of an attack made by a marauding band of Arabs, under his leadership, upon a town. He had ordered the attack, and the Arabs had declined, saying that the moon was full. The inhabitants of the town were unprepared, believing that the full moon would protect them. What they did not know, and Lawrence did, was that there was to be an eclipse of the moon. The outpost was taken.

The question of sunrise and sunset, of course, is too obvious to dwell upon. But a knowledge of sunspots, with the possible resulting auroras, is a refined detail we might not think of. When the "Royal Oak" was sunk, the report brought confirmation by the statement that the ships were silhouetted against the Northern Lights, and the biggest one had been torpedoed.

Every British naval officer is required to have a copy of a book called **The Military Uses of Astronomy.** This little work gives an outline of astronomy, with thumbnail rules for telling degrees, measuring the distance of the horizon from the height of the observer, telling time, and other things useful to men in the field.

Most of the facts needed for the application of astronomy to war can be learned in a short time, by people who have never had any particular interest in the stars. But the value of these facts should be made known before there is too little time to learn them.

Reprinted from THE OBSERVER *"Defense Issue" November, 1941, published by the Amateur Astronomers of The Franklin Institute.*

Sky and TELESCOPE

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The Editors Note . . .

NOW that we are at war, we must call the attention of our readers and of amateur astronomers in particular to the November "Defense Issue" of **The Observer,** published by the Amateur Astronomers of The Franklin Institute, Philadelphia. So pertinent to the present situation are the contents of this four-page bulletin, that in the adjoining column we reprint one article.

Without doubt, every society of amateur astronomers could make a list of its members now actively engaged in defense "doing work that they have either learned, or become interested in, as a result of their affiliation . . ." with the society.

The A.A.F.I.'s own list is imposing, but the message brought with it is most important: ". . . the interrelation between the amateurs and the professionals (defense workers) is too complex for a complete separation. The one can contribute vastly to the other, and in these times of urgent need, both must work together." And further, "Amateurs can supply one thing that the National Roster, with its professional personnel, can't give—numbers! . . . You can't find enough professional astronomers to watch for one city, and besides, there's no sense in using them for such a purpose."

Last month we published an eclipse report from amateur astronomer Foster D. Brunton, of Agana, Guam, and in this number (pp. 12-13), from Father Pablo Guzman-Rivas, at the Manila Observatory, appear photographs of the recent occultation of Mars. We can but hope that these contributors are safe and well, and still astronomically active.

With regard to her statement in the **Ladies' Home Journal,** which we mentioned last month, Mrs. Eleanor Roosevelt recently wrote in her newspaper column, "My Day," in part:

"I have just been sent a report . . . written by Dr. Bart J. Bok and Margaret Mayall. Both of them are astronomers, and the report is written to prove that too many people put faith in astrologers. . . . They take me to task for not having been firmer in an answer to a question. . . . I can only say that I fear I have never taken any form of fortune telling very seriously."

VOL. I, NO. 3 JANUARY, 1942

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COVER: A portrait of Galileo which was first printed in his book on sunspots (Reference 2), and used again as a frontispiece in various other books. The cherub on the left holds one of Galileo's "geometrical and military compasses." The one on the right holds one of Galileo's telescopes, which in their early form were trumpet-shaped. (See article on page 3.)

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The Starry Heavens in January 26

BACK COVER: Saturn, photographed by Barnard with the 60-inch reflector at Mt. Wilson.

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation. Publication office: 91 Huguenot Street, New Rochelle, N. Y. Editorial and general offices: Harvard College Observatory, Cambridge, Mass.

Subscription: $2.00 per year in the United States and possessions; $2.50 foreign (including Canada). Single copies: 20 cents. Make checks and money orders payable to Sky Publishing Corporation; send notice of change of address 10 days in advance to editorial and general offices.

Entered as second class matter, April 28, 1939, at the Post Office, New Rochelle, N. Y., under Act of March 3, 1879. Additional entry at the Post Office, Boston, Massachusetts, applied for December 16, 1941.

DIALOGO
DI
GALILEO GALILEI LINCEO
MATEMATICO SOPRAORDINARIO
DELLO STVDIO DI PISA.
E Filosofo, e Matematico primario del
SERENISSIMO
GR. DVCA DI TOSCANA.
Doue ne i congressi di quattro giornate si discorre sopra i due
MASSIMI SISTEMI DEL MONDO
TOLEMAICO, E COPERNICANO;
Proponendo indeterminatamente le ragioni Filosofiche, e Naturali tanto per l'vna, quanto per l'altra parte.
CON PRI VILEGI.
IN FIORENZA, Per Gio: Batista Landini MDCXXXII.
CON LICENZA DE' SVPERIORI.

DIALOGO
di
GALILEO GALILEI LINCEO
AL SER.mo FERD. II. GRAN. DVCA DI
TOSCANA

The title page and frontispiece of Galileo's great treatise on the Copernican system of the world as contrasted with the Ptolemaic. (Reference 3.) His name appears as "Galileo Galilei Linceo," indicating that he was a member of the "Lincei," the Society of Lynxes, which group of scientifically-minded persons sponsored the publication of the book. It was written in the form of a dialogue among three characters, whom the frontispiece shows engaged in active discussion of the problems with which the book is concerned.

THE ASTRONOMICAL WORK OF GALILEO GALILEI (1564–1642)

By I. Bernard Cohen
Fellow of the Carnegie Institution of Washington

JANUARY 8, 1942, marks the 300th anniversary of the death of one of the greatest astronomers that ever lived, Galileo Galilei. Galileo died on January 8, 1642, Gregorian (the style of calendar used at that time in Italy). Within a year of his death, Isaac Newton was born, on December 25, 1642, Julian (the calendar then used in England), which was January 4, 1643 (Gregorian). Thus there was continuity in the current of scientific genius. Galileo's career and Newton's are similar in many ways—both made important contributions to mathematics, physics, theoretical astronomy, the use of scientific instruments—of the telescope in particular. And both made vital contributions to the understanding of what science is, what its methodology is, and what it can do. Readers of *Sky and Telescope,* however, have reason to be chiefly concerned with Galileo's achievements as astronomer, and the present article is devoted mainly to that subject.

Galileo's discoveries in mechanics alone (described by him chiefly in Reference 4) entitle him to an important place in the history of science. But since he turned his talents to astronomy, let us now see what results those talents were able to achieve.

Galileo's interest in astronomical matters was aroused by a "new star" which was seen in the sky on October 10, 1604. This nova was the most brilliant object in the heavens with the possible exception of Venus, and it aroused a great deal of attention, just as an earlier one had done in 1572, when Tycho Brahe was attracted to astronomy by the nova observed in Cassiopeia. Aristotle had taught that the heavens were immutable and could not change, that stars could neither be created nor destroyed. The strict followers of Aristotle and Ptolemy were concerned, therefore, to "demonstrate" that the "new star" was no star at all but an illusion—a "collection of vapors" in the sky, or something like an aurora. Galileo, glad to find an opportunity to attack older astronomical thought, gave three public lectures in which he showed that this new star was like all other stars except in so far as it was "new," a nova.

He had already come to doubt the laws of mechanics as taught by Aristotle; now he had further evidence of the inadequacy of Aristotle's dicta concerning astronomical matters. We know that he was already an ardent advocate of the Copernican system as opposed to the Ptolemaic, because of a letter which he wrote to Kepler in August of 1597, some years earlier. Kepler had requested that Galileo read his writings, and Galileo replied, "This I will do all the more gladly, since I adopted the opinion of Copernicus many years ago; and from

such a standpoint I have arrived at explanations of many phenomena of nature which, without doubt, are inexplicable according to the more usual [i.e., Ptolemaic] hypothesis."

But the most important event in Galileo's career as astronomer occurred in 1609. He writes:

> Ten months ago, nearly, a rumor came to our ears that an optical instrument had been elaborated by a Dutchman, by the aid of which visible objects, even though far distant from the eye of the observer, were distinctly seen as if near at hand; and some stories of this marvelous effect were bandied about, to which some gave credence and which others denied. The same was confirmed to me a few days after by a letter sent from Paris by the noble Frenchman Jacob Bavodere, which at length was the reason that I applied myself entirely to seeking out the theory and discovering the means by which I might arrive at the invention of a similar instrument, an end which I attained a little later, from considerations of the theory of refraction; and I first prepared a tube of lead, in the ends of which I fitted two glass lenses, both plane on one side, one being spherically convex, the other concave, on the other side.

With these words did Galileo begin his book entitled *The Starry* [or *Sidereal*] *Messenger* (Reference 1) in which he described what he had accomplished by means of the new instrument. The Preface to this book is dated March 4, 1610, and Galileo's invention, or reinvention, of the telescope was apparently made in June or July of 1609. The early form of Galileo's telescope appears to have been trumpet-shaped, as may be seen from the illustration on the front cover, but later he made use of a straight leaden tube.

The Starry Messenger begins with a description of the moon, the first object of Galileo's telescopic attention. His instrument was not sufficiently powerful to show much detail; it was hardly as effective as a better-grade modern field glass. Yet, until this time, no one had seen the moon magnified at all, and most astronomers believed it to be a smooth globe—clear and perfect as befitted a celestial object. Many explanations of the "apparent" dark spots had been invented—a typical example is in Dante's *Paradiso,* Canto II.

Galileo noticed many smaller markings on the moon's surface, and correctly identified the bright spots seen near the terminator as mountain tops shining in the sunlight, while the surrounding lunar area is still in darkness. With precision and ingenuity characteristic of his research, he calculated the height of the more conspicuous mountains on the moon, estimating that the largest must be in the neighborhood of four miles high, a figure closely agreeing with modern observation and calculation. But the most important part of his observation was the fact that the moon greatly resembles the earth, having mountains and rough spots, and large dark spots which he thought (erroneously) were due to the presence of water, and

The Beehive Cluster in Cancer, drawn by Galileo, and called by him in the language of his times, "Beehive Cloud." (From Reference 1.)

thus named "seas." He doubted the existence of lunar *seas,* however, in a later book (Reference 3).

He next turned his telescope to the fixed stars, and found that the glass did not appreciably magnify the size of the stars, but that it appeared to increase their number vastly. Thus he was able to see many stars, the view of which had been denied to his predecessors. Galileo was able to count 36 stars in the Pleiades, while unaided vision reveals only seven. He found that portions of the Milky Way and certain nebulous patches of light consist of multitudes of faint stars grouped together in clusters. In the cluster Praesepe in the Crab, to cite one example, he counted two score stars.

The greatest of Galileo's discoveries he recounted last; it concerns the four new "planets"[1] which he described as "never seen from the first beginning of the world until our time."

On January 7, 1610, Galileo turned his telescope toward Jupiter. He noticed that it presented a round appearance much like the sun and the moon; its disk was of greater magnitude than the inferior planets, but, save for the matter of size, there was no apparent difference between the inferior planets and the superior planets.

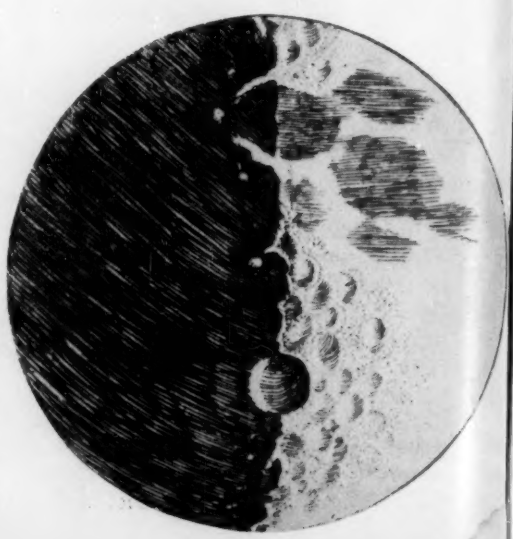
On close examination, he noticed three very small but bright "stars" in the vicinity of Jupiter, two to the east of the planet, and one to the west. He imagined them to be fixed stars, but he could not help but be struck with the unusual fact that they were disposed with Jupiter in a straight line which was parallel to the ecliptic. Chancing, by merest accident, to look again at Jupiter the following night, he was surprised to find that these three "stars," still arrayed in a straight line, were all of them to the west of the planet and nearer to each other than the preceding night. At first, our astronomer thought that Jupiter had got in advance of the stars by means of its proper motion and that its motion might therefore be "direct." But he was unable to test this supposition on the next night owing to clouds.

And so he had to wait another night. Then on January 10th, he observed only two "stars," now to the east of Jupiter, and he supposed that the third was concealed by the planet itself. At this point he was unable to account for the phenomenon by means of the motion of Jupiter, and he wondered whether the apparent motions should be referred to the "stars" themselves, rather than to the planet. Here was a matter of great importance and he decided to give it his closest attention.

On the 11th, he again saw two "stars" to the east of the planet, but one now appeared twice as large as the other. This fact, together with the constant change of the position of these "stars" relative to Jupiter, and the complete disappearance of one of them, gave him the key to their real character: There are three "stars" revolving around Jupiter just as the planets revolve around the sun in the Copernican system. On the 12th, Galileo saw three "stars," again, but on the 13th of January, he finally saw four of them. On the 14th he again saw four. His future observations left no doubt that these were satellites of Jupiter.

Soon after the publication of his book, Galileo discovered the existence of sunspots. Although he was probably the first person to see spots on the sun, he was not the first to publish his observations. He

The surface of the moon as seen by Galileo and pictured by him in his *Starry Messenger*.



[1]The term planet was at that time applied to any celestial body which moved with respect to the fixed stars; e.g., the sun and moon were called "planets."

saw them in Padua early in 1610, but did not publish an account of them until 1613 (Reference 2). Their existence was of double interest to Galileo. First, they proved to him that the sun was not perfect, as the older astronomers had taught, but was covered with imperfections. Second, from the movement of these spots, he was convinced that the sun rotates about its axis, and calculated its period of rotation.

Another discovery made in the year 1610 was the phases of Venus. He announced this on December 11, 1610, in the form of an anagram as follows:

Haec immatura a me jam frustra legentur
o·y

which can be translated as: "These immature things are read by me now in vain." Kepler tried to unscramble the anagram and got: "There is a red spot on Jupiter; it rotates mathematically, etc." And then Galileo showed that it really meant: *Cynthiae figuras aemulatur mater amorum,* which means, "The mother of loves [which is Venus] emulates the figures of Cynthia [the moon]." In other words, Venus has phases just like the moon. The moon, the earth, and the other planets, all shine by the reflected light of the sun. Except for the fixed stars, only the sun shines by its own light.

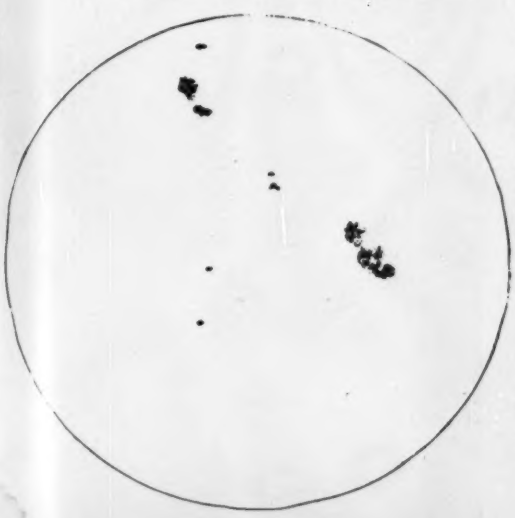
This chain of discoveries in descriptive astronomy had strong theoretical consequences in Galileo's mind. They all were grist for the Copernican mill and each of them was a blow struck at the Ptolemaic system. Let us consider them in the order in which they were made and in which they have been described.

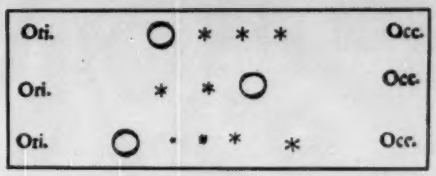
1. The nova of 1604 showed that the ancients were wrong in declaring that there could be no "new stars."

2. The observations of the moon showed it to be like the earth in appearance.

3. The existence of the myriads of stars shown by the telescope proved the unreliability of ancient writers who had never seen these telescopic stars.

Galileo's representation of the spots on the sun (Reference 2). From the regular movement of sunspots, Galileo deduced the rotation of the sun about its axis.





The satellites of Jupiter as observed on successive nights by Galileo. These pictures are the first ever made of Jupiter's moons. (From Reference 1.)

4. In the telescope the fixed stars appeared as mere luminous points, so that the apparent diameters of several minutes of arc, attributed to them by previous observers, were proved to be nonexistent.[2]

5. The discovery of the satellites of Jupiter presented Nature's model of the Copernican system in operation, and put an end to the difficulty raised by those who asked why the moon alone formed an exception to the general rule by moving around a planet instead of around the sun.

6. The discovery of sunspots supplied a striking refutation of the Aristotelian doctrine of the perfection of celestial objects, and indicated that the sun, like the earth and moon, rotated about its axis.

7. The discovery of the phases of Venus showed that the fixed stars and the sun alone emit light of their own, while the planets are non-luminous. Thus the fixed stars, "to use the words of [Giordano] Bruno, are suns, the planets are moons or earths," as Kepler wrote with joy to Galileo.

Firmer than ever in his conviction that the Copernican system represented the only true picture of the solar system, Galileo spent the years from 1625 to 1629 writing a treatise that he intended to be "the sum and culmination" of his life's work. This was the famous *Dialogues concerning the Two Principal Systems of the World, the Ptolemaic and the Copernican* (Reference 3). Despite the avowal of impartiality and even of favor to the Ptolemaic system, this book was an effective and crushing attack on Ptolemaic astronomy and a convincing proof of the Copernican system.

The result, as everybody knows, is that Galileo was brought before the Inquisition, and there did he "abjure, curse, and detest" his "errors and heresies," while his book was placed on the *Index*. The Inquisitors were relatively lenient; they allowed him to teach and to continue with his work, and he not only wrote his *Dialogues on Two New Sciences* (Reference 4), but he was able to make another astronomical discovery, namely, the libration of the moon. (See Observer's Page.) Galileo was the final victor. His works were eventually removed from the *Index* and a Vatican Observatory was founded.

Whether or not Galileo actually invented the telescope, or whether, as he says himself, he reinvented it, makes little difference. The important thing is that he was the first person to use a telescope to view the heavens. With the insight which is the characteristic of genius, he grasped at once what purposes the new instrument might serve. In every direction in which he looked with the telescope he saw something new—the moon, the Milky Way, Jupiter, the sun, Venus. He had an experience which was unique in the history of mankind; he was the first person to view a hitherto-undiscovered universe, the very nature of which had been unknown to all members of the human race before him. And his genius made the most of his opportunity.

[2] This, according to Dreyer, "swept away the very serious objections raised by Tycho [to the Copernican system] that a star having no annual parallax and yet showing a considerable apparent diameter must be incredibly large."

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4. **Discorsi e dimostrazioni matematiche intorno à due nuove scienze** . . . (Leyden, 1638).

4a. **Dialogues concerning Two New Sciences by Galileo Galilei.** Translated by Henry Crew and Alfonso de Salvio. (New York, 1914; New York, 1933; Evanston, Ill., 1940).

ANNIVERSARIES

One hundred years ago, in 1842, many events of astronomical importance occurred. Agnes Clerke's "History of Astronomy in the Nineteenth Century" lists the following:

"Doppler's principle of the change of refrangibility of light by motion announced.

"Conclusion of Baily's experiments in weighing the earth.

"July 8. Total solar eclipse. Corona and prominences observed by Airy, Baily, Arago, and Struve."

Fifty years later, in 1892, we find:

First trustworthy results of application of Doppler's principle to the stars—Vogel's radial velocities of 51 stars.

The discovery by Anderson of Nova Aurigae, prototype of Nova Herculis, 1934.

The first photographic discovery of a comet, by Barnard.

Chandler's interpretation of the inequalities of Algol's light period as caused by presence of a third invisible star. (Dr. Zdenek Kopal will discuss Algol in **Sky and Telescope** in the near future.)

THE DOUBLE STAR 61 CYGNI

By K. Aa. Strand

Sproul Observatory, Swarthmore College

One of the 19th century's greatest astronomers (1784-1846). Besides his many contributions to fundamental astronomy, his successful measurement of the parallax of 61 Cygni, his discovery of the variable proper motion of Sirius and Procyon, Bessel is famous for his work in geodesy and geophysics.

"ESTEEMED SIR:—Having succeeded in obtaining a long-looked-for result, and presuming that it will interest so great and zealous an explorer of the heavens as yourself, I take the liberty of making a communication to you thereupon. Should you consider this communication of sufficient importance to lay before other friends of Astronomy, I not only have no objection, but request you to do so."

These are the opening words of a letter dated October 23, 1838, in which is described how the first distance measure of real scientific value was obtained for a star. The letter, addressed to Sir John Herschel in England, was written by Friedrich Wilhelm Bessel, director of the observatory in Königsberg, Germany.

The instrument used was a so-called heliometer built in 1826 by the famous German optician, Fraunhofer. A detailed description of this type of telescope would be beyond the scope of this article. Briefly, it is a refractor with the objective cut into halves which can be shifted with respect to each other by means of precision screws. Bessel's success showed the superiority of the heliometer over the meridian circle and the early type micrometer for the special field of accurate measurements of short arcs on the celestial sphere. Only the modern method of photography with long focal-length telescopes has surpassed the heliometer in accuracy.

The star chosen by Bessel for his investigation was 61 Cygni, a double star of the 5th magnitude in the constellation of the Swan. This object had already attracted attention in 1806 when the Italian astronomer, Piazzi, discovered its unusually large proper motion (5".2 annually) for which reason it became known as the "flying star." In 360 years its "flight" across the celestial sphere equals the apparent diameter of the moon. This was the largest known angular motion until discoveries in this century brought it down to fifth place, the largest known proper motion now being that of the 10th-magnitude star discovered by E. E. Barnard. Barnard's star has a proper motion of 10".3 annually, or almost twice that of 61 Cygni.

Bessel was aware of the fact that previous unsuccessful attempts to measure stellar parallax simply indicated the smallness of this quantity even for relatively nearby stars, and that in order to meet with success, a star should be chosen which was likely to have a sensible parallax. Modern research has revealed that the range in motion of stars is much less than the range in intrinsic brightness. The proper motion of a star is, therefore, a fairly good criterion of distance. Bessel's choice of this criterion was rewarded. He found the distance of 61 Cygni to be 3.19 parsecs (10.4 light-years) with an accuracy of 1/15 of the measured amount; Bessel's first value is only seven per cent smaller than the mean result of the modern photographic determinations.

As early as 1753, 61 Cygni was observed as a double star by Bradley at the Greenwich Observatory. The observed separation of the two components was 20 seconds of arc and their position angle 35 degrees. (The position angle is the angle at the primary star between the direction of the companion and that of the north celestial pole; it is measured counterclockwise from north through east, around the circle.) Twenty-five years later (1778) Cristian Mayer, a Jesuit astronomer from Mannheim, Germany, observed the star and found that the separation had decreased to 15 seconds of arc and the position angle had increased to 51 degrees. When Bessel observed the star in 1812, the separation was about 17 seconds of arc and the position angle was 79 degrees, thus establishing beyond any doubt a considerable relative motion of the components.

These early observations were made with mural quadrants and transit instruments of rather primitive construction and do not possess any high degree of accuracy, so that deviations of several degrees in position angle and a few seconds of arc in distance from the actual values can be expected. Visual observations of a much higher degree of accuracy were not obtained until 1824 when F. G. W. Struve, in Dorpat, Russia, started his micrometer observations of the relative positions of double stars with a 10-inch refractor constructed by Fraunhofer. In spite of the fact that his measures were made more than a century ago they are unsurpassed in accuracy by the best modern visual observations. During the 19th century a large proportion of astronomers devoted their time to double-star observations and a list of the observations made of 61 Cygni reveals the names of all the outstanding observers. Besides Bessel and W. Struve we find men like O. Struve, Kaiser, Maedler, Dembowsky, Dunér, H. Struve, Asaph Hall, and Schiaparelli.

The micrometer measures of such a wide pair as 61 Cygni have now been entirely replaced by a photographic method giving errors nearly 10 times as small as those of the best visual observations. The method was developed by the Danish astronomer, Ejnar Hertzsprung, in 1914, and has been fully described by the writer in a recent article in The SKY (May, 1941). For 61 Cygni extensive material of this high accuracy is at hand covering the period 1914-1941. The plates have been taken with the large visual refractors of the

Not far from the bright star Deneb, at the top of the Northern Cross, is 61 Cygni (in circle), the first star for which a reliable distance was obtained. This Harvard Observatory photo shows its position among other naked-eye stars.

Potsdam (focal length 41 feet, scale 1 mm. = 16″.38), Lick (58 feet, 11″.72), and Sproul (36 feet, 18″.87) observatories. On the Sproul plates alone, no less than 19,000 settings with the measuring machine were made for this object by Miss Virginia Burger and the writer. It should be mentioned that the relative positions of the two components were obtained by means of photography long before Hertzsprung developed this method, but in all those cases the accuracy is not comparable with that yielded by this method.

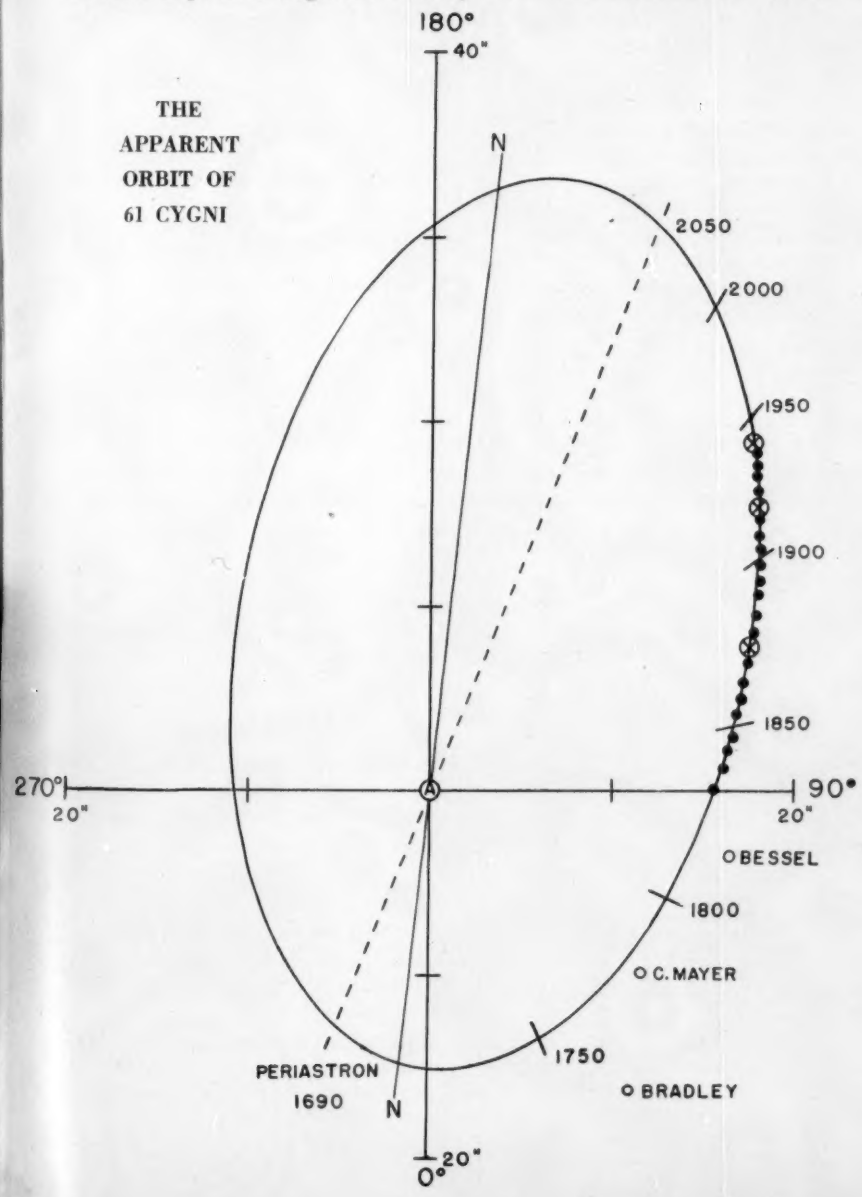
The first photographs on record ever taken of 61 Cygni were by Lewis M. Rutherfurd of New York City. The instrument was a refractor of 13-inch aperture and 13-foot focal length. Between 1871 and 1874 he took 19 plates, each having two exposures. Photography was still in its infancy and the so-called wet process was still in use. The emulsion had to be coated on the glass by the observer himself and exposed before it would dry. Although these plates are nearly 70 years old, they are still in excellent condition and show a remarkably fine-grained emulsion. The plates were placed at the writer's disposal through the courtesy of Dr. Jan Schilt, director of the Rutherfurd Observatory of Columbia University. Because of their early date and because they could be measured and reduced in the same way as the modern material, these plates have played an important role in the orbit computations described below.

The nature of the relative motion of the two components was widely discussed during the 19th century. On account of the wide separation, the observed orbital motion has been rather slow, and moreover, has only shown a very slight curvature. This had led to the belief that the two stars were without physical connection, but had slightly different motions in different depths of space. The probability for such an arrangement is extremely small, but it was accepted by several astronomers even up to the beginning of this century, although N. C. Dunér, as early as in 1876, was able to show a slight curvature from the available observational material. Modern observations, including parallax determinations, have established the close physical connection of the two components beyond any doubt.

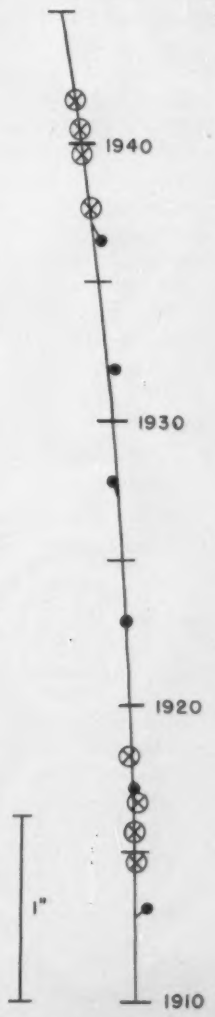
The determination of the character of the orbital motion of a visual double star like 61 Cygni is a very simple problem from the theoretical point of view. The stars are so remote from other celestial bodies that we are dealing with the motion of two bodies only, held together by their gravitational attraction. From the law of gravitation it follows that the relative motion in such a case is an ellipse (Kepler's first law), the true orbit, with the primary star in one focus; further, that the areas swept over by the radius vector in equal times are equal (law of areas or Kepler's second law). The observed orbit is the projection of the true orbit on the plane perpendicular to the line of sight; this apparent orbit must also be an ellipse and Kepler's second law must, of course, also be fulfilled by the apparent motion of the companion relative to the primary. Once the apparent orbit is determined, the real orbit can be computed together with its inclination to the line of sight, except that we do not know which end is tipped toward us; this must be determined from spectroscopic observations. Knowing the mean distance (semi-axis major) of the true orbit (a), in seconds of arc, the period of revolution (P) in years and the parallax of the system (p), the total mass of the system in terms of the sun's mass is equal to $a^3/p^3 \cdot 1/P^2$ (Kepler's third law).

The practical solution of the problem of the orbital motion in the case of 61

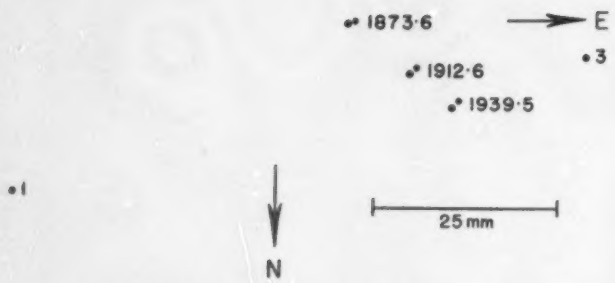
THE APPARENT ORBIT OF 61 CYGNI



Left: The ellipse shows the computed apparent motion of the faint component with respect to the bright component at A. The true orbit is inclined 52 degrees around the line of the nodes, N-N. The dots represent five-year means of the visual observations, the symbol (×) represents photographic observations.



Right: The orbital motion of 61 Cygni from 1910 to 1945 on a scale 10 times that of the complete orbit. This enlarged section of the orbit illustrates the superior accuracy of the photographic observations. The yearly means of the photographic positions (×) deviate very little from the computed orbit as compared with the five-year means of the visual observations.



The heliocentric positions of the two components at three different epochs on the scale of the Sproul plates. The positions for 1873 are those obtained from Rutherfurd plates and have been transformed to the scale of the later Sproul observations. The reference stars 1, 2 and 3 are those used in van de Kamp's recent determination of the mass-ratio and parallax.

Cygni is hindered by the fact that only a small part of the orbit is covered by accurate observations; moreover, the observational material itself is not at all homogeneous as far as the accuracy is concerned. Previous investigations by the writer have shown that the visually observed distances are frequently affected by systematic errors even though they are the means of many observers as in the present case. It was, therefore, of importance that these distances could be excluded from the computations since the photographic observations gave a highly accurate value for the areal velocity. The orbit was thus determined from the photographic positions and the visually observed position angles.

The writer has no intention to give in this article a detailed account of the elaborate computations recently carried on at the Sproul Observatory by Miss Burger in order to obtain a full discussion of the problem. It should be mentioned, however, that no less than 20 different orbits were tried out, testing periods of revolution from 550 years up to 850 years. These computations showed clearly that without the photographic observations no orbit of any degree of accuracy could have been obtained at the present time.

The results of the computations are as follows: The true orbit is an ellipse with an eccentricity of .41 and an angular mean distance of 24.64 seconds of arc. The period of revolution was found to be 720 years; the closest approach of the components (periastron passage) occurred in 1690. The uncertainty of the period is not likely to exceed 10 years either way.

We shall now transform the angular dimensions of the orbit into absolute values by using an adopted parallax of 0".294, or a distance of 11.1 light-years; this value is based on all modern photographic parallax determinations. The mean distance of the true orbit then becomes 24.64/.294 = 83.8 A.U. (one astronomical unit is equal to the distance sun-earth) and the total mass of the system is 1.16 that of the sun. Recently, Dr. Peter van de Kamp has made a provisional determination of the ratio of the two masses from photographic material exclusively. His result would give masses of 0.73 and 0.43 that of the sun for the two components. The difference in mass is probably less than these values indicate, but it is clear that both stars are less massive than our sun—which is to be expected since both stars are red dwarfs with luminosities of only 7/100 and 4/100 that of the sun.

The present separation of the components is 110 A.U., which is nearly three times the distance of Pluto from the sun. Their relative velocity is 2½ km./sec. or 1/12 the velocity of the earth around the sun. At their closest approach in 1690, the stars were 50 A.U. apart and their relative velocity was 5½ km./sec. In 2050 the stars will have their largest separation, 118 A.U., and their relative velocity will be 2¼ km./sec.

Radial-velocity determinations show that the system is approaching our solar system at the rate of 13 A.U. per year (63 km./sec.). Thus the dimensions of the apparent orbit are increasing gradually due to this perspective effect. Even though the system is 700,000 A.U. away, the secular increase in angular separation is no less than 1.36 per cent for each revolution. This means that the present separation (about 26 seconds of arc) will have increased by 0".35 when the companion returns to the same position in the orbit 720 years hence. In the present orbit computation this has necessitated an adjustment for distance of the observations to one and the same epoch. For example, observations made 25 years ago had to be increased by the amount of ".012, which is twice the accuracy with which the photographic places are known!

There have been some speculations on the presence of a third component in the system giving rise to perturbations in the orbital motion. In spite of their much higher accuracy, the photographic plates taken by Hertzsprung and the writer have not shown any sign of perturbation so far. Even though the present investigation has been concluded, the star is being kept on the observing program at the Sproul Observatory. Six plates, taken each year, provide us with material accurate enough to permit the detection of perturbations as small as 0".012. For example, we would be able to find a satellite revolving around one of the components in a period equal to that of Jupiter (12 years), even if its mass would be no more than six times that of Jupiter, or 6/1,000 that of the sun.

DO YOU KNOW?

By L. J. Lafleur

I. Score four points for each question correctly answered, and one point for each question where you do not attempt to select the answer.

1. On a January evening in the northern states you would not expect to see the constellation
   a. Pisces c. Pegasus
   b. Orion d. Libra
2. If the crescent moon is seen at midnight, it cannot be
   a. east of the observer
   b. west of the observer
   c. near the zenith
   d. near the horizon
3. A comet which broke into two parts was
   a. Halley's c. Donati's
   b. Biela's d. Herschel's
4. The length of a degree of latitude at the equator is
   a. 69.4 miles c. 76.3 miles
   b. 73.6 miles d. 86.4 miles
5. There is no 1st- or 2nd-magnitude star in
   a. Hercules c. Ophiuchus
   b. Hydra d. Eridanus
6. A telluric line is a spectroscopic line
   a. due to the interference of radio waves
   b. originating in the earth's atmosphere
   c. found originally in the spectrum of Saturn's rings
   d. of tellurium
7. A thousandth of a millimeter is indicated by the symbol
   a. λ. b. $\lambda\lambda$ c. μ d. $\mu\mu$
8. One of the following is not a figure of equilibrium for a homogeneous rotating body:
   a. sphere c. prolate spheroid
   b. oblate spheroid d. pear-shaped figure
9. An annular eclipse occurs
   a. every year
   b. when the moon is near apogee
   c. only near the equator
   d. when the moon is full
10. One of the following constellations lies on the ecliptic:
    a. Ursa Minor c. Canes Venatici
    b. Pisces d. Lepus

II. Each of the following figures is important in astronomy. Can you identify them? Count five points for each one identified.

a. 2.512 c. 3934 e. 6.55×10^{-27}
b. 864,100 d. 23° 27′ f. —26.6

III. A number of steps are required in the solution of the following problem. Partial credit will be allowed. (Total credit, 30 points.)

If the earth's diameter were halved, its average density and the density of the atmosphere remaining constant, how high could the ordinary man jump?

(*Answers on page 21*)

HOW TO MEET THE FIFTH COLUMN IN ASTRONOMY

By W. Carl Rufus, *University of Michigan Observatory*

We present the text of a talk given by Prof. Rufus before the Detroit Astronomical Society on October 12th. His own horoscope, which he drew and decoded before that audience, is included too.

MY interest in astrology is due to an attempt to be professionally co-operative. Michigan Papyrus No. 1, brought from Egypt several years ago, is an astrological treatise based on astronomical data. After the Greek professors at the University of Michigan had plugged the worm holes with alphas and betas and translated the patchwork, they appealed to an astronomer to interpret its meaning, if any. It turned out to be a unique system unknown previously in the history of astrology. To check results I wrote my own horoscope, which, according to Mrs. Rufus, gave a characterization quite illuminating, if true, although at some points it was not very complimentary, true or false.

On the bulletin board announcing my extension course in Detroit one fall, was neatly lettered *Astrology, Room 614.* The mistake caught in time to save my reputation, *Astronomy* was substituted. Later in the course, during an intermission I overheard a conversation regarding horoscopes. One of the school teachers in the class had just invested in a reading. Again professional altruism prompted me to rush in.

"Would you like to learn to read your own horoscope?" I inquired. In great surprise another question, "What! Can you write a horoscope?" "Yes," I admitted. "But will it be authentic?" "Sure, just as authentic as any." An extra evening was proposed, the privilege of inviting friends was extended and we had the largest attendance of the year.

This method of dealing with the fifth column in astronomy has the advantage of meeting its professors on their own ground. Various astrological systems have been devised by the ingenuity of human agencies and one man has just as much right to his system as another. In that way in a democratic country, if the astrologers do not predict its downfall, we can enjoy the application of astrology as a game or as an amusement without paying for it and without taking it too seriously.

We recall the amusing method used by Swift, the great English satirist. In his brochure, "Prediction for the Year 1708, by Isaac Bickerstaff, Esq.," he begins by displaying great confidence in the art and claims knowledge of a superior method. Then he proceeds: "My first prediction . . . refers to Partridge, the almanac maker. I have consulted the stars of his nativity by my own rules and find that he will infallibly die upon the 29th of March next about eleven at night of a raging fever. Therefore I advise him to consider of it and settle his affairs in time."

Swift followed this by a letter to a well-known Englishman giving an account of the death of Partridge on the day and near the hour predicted. The victim protested that he was alive and induced a friend to bear witness with a pamphlet. Then Partridge published his 1709 almanac, which Swift termed irrelevant evidence: "for Gadburg, Poor Robin, Dove and Way do yearly publish their almanacs, though several of them have been dead since before the Revolution."

Amusement and satire are not sufficient, however, for this discussion. I would not feel justified in ridiculing or condemning that which I do not understand. A scientist, even an astronomer, must look upon astrology from an objective point of view, as he does on other human inventions and activities. He must consider its claims honestly and openly without bias or prejudice. He must accept its long history, its early origin and rapid progress, its world-wide conquest, its direction of state affairs in the Far East, its dominating influence at European courts during the medieval period, its practice by outstanding scientists up to the 17th century, and its tenacious grip on the popular mind even to the present day.

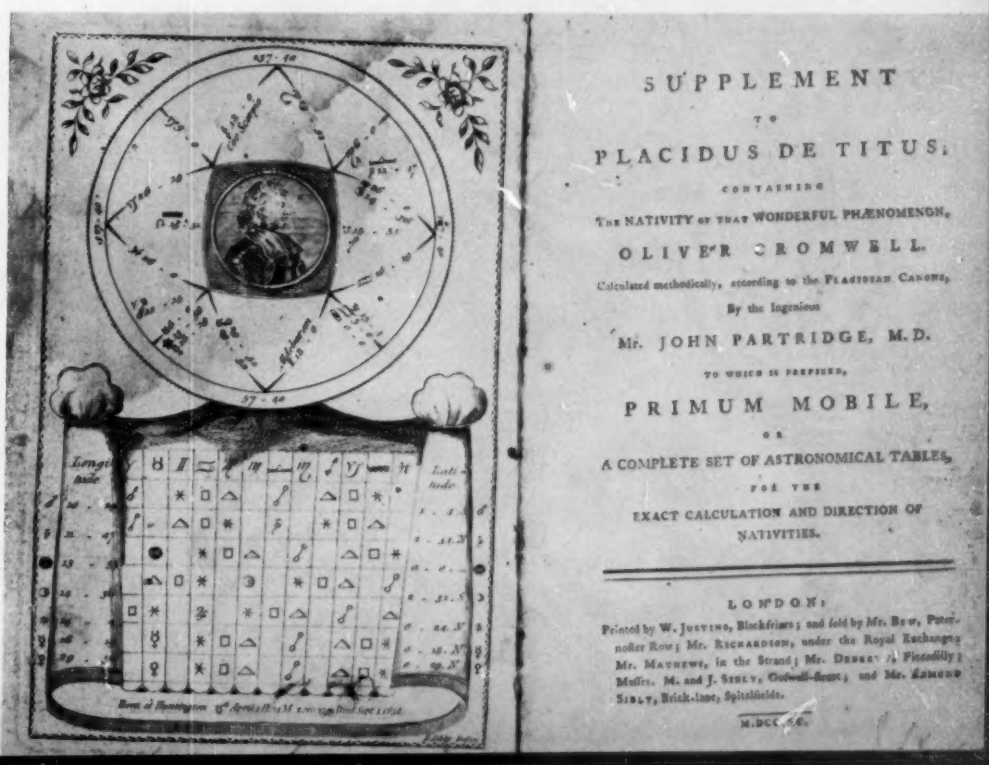
Recently, a London reporter stated in his daily broadcast that astrology is increasing in influence in England and is more potent in developing war psychology than the newspapers and official reports. One astrological organ in England has a circulation of over one million. In the United States, right here in Ann Arbor and Detroit, you may find at newsstands a half dozen or more astrological magazines. The other day I picked up several standard works on astrology from stock on hand at one University bookstore, and in the stacks of the University library are a large number of volumes on the subject.

Astrology has been hailed as the forerunner of astronomy. Probably it would be more accurate to say that they originated together and there was no indication of separation until the period of the Greek philosophers. The word *astrology* means the science of the stars, analogous to geology, the science of the earth.

Its origin is lost in antiquity. In an attempt to explain its early influence we accept the idea that primitive man observed the rising and setting sun, enjoyed the warmth of the day, and attributed benevolent virtue to this most conspicuous heavenly body. Soon the moon and the planets were added to the gods of the ancient world. The natural time periods of the day, the month, and the year, marked the recurrence of observable phenomena.

But the week as a time unit has no such basis. Its origin seems to have been

The frontispiece of a book published in London in 1790. John Partridge was the astrologer whose death Swift had predicted.



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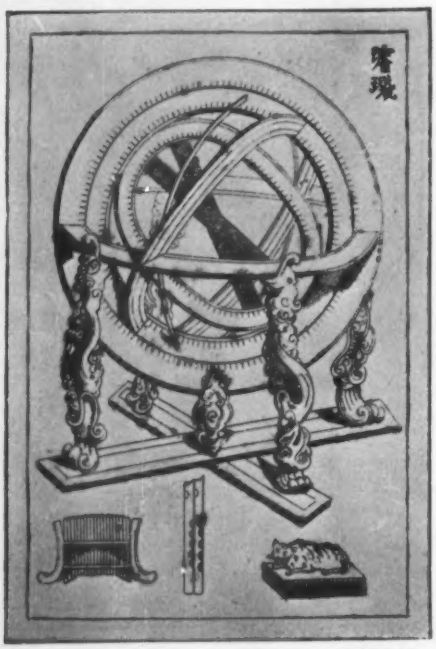
M.DCC.XC.

an astrological counterpart of the astronomical phenomena. The seven planets or moving bodies of the ancients, beginning with the most remote, are Saturn, Jupiter, Mars, Sun, Venus, Mercury, and Moon. The sun, more distant than the moon, had greater influence, so Saturn, the most distant, was assigned first in the established order. It was made the ruler of the first hour of the first day of the week. Assigning the successive hours of the day to the planets in the established order, the first hour of the second day belonged to the sun. The first hour of the third day belonged to the moon. Continuing the process it is easy to see that there will follow Mars, Mercury, Jupiter, and Venus. The English names of the first three days remain recognizable—Saturday, Sunday, and Monday. You may trace the others in various languages. The week of seven days constitutes a permanent monument to primitive astrological influence.

The naturalistic pantheon increased, but these seven became the most outstanding of the gods that controlled the destiny of man in the system of astrology that developed in the ancient world, was standardized by Ptolemy, and has come down to the 20th century.

Several branches of astrology developed side by side, of which we here mention two. The first was *natural astrology,* which dealt with the prediction of eclipses, conjunction of the planets, return of the seasons and other natural phenomena. The second was *judicial astrology,* judging the influence of the heavenly bodies on human affairs, which predicted the acts and fate of men and nations. Strange as it may seem, both of these types of prediction, natural and judicial, had the same philosophical basis in the period of the ancients. Eclipses were predicted by empirical rules long before physical laws were found to explain the apparent motions of the sun and the moon. The precession of the equinoxes was known and star positions were corrected for it 1,500 years before Copernicus gave a physical explanation of the phenomenon. These empirical results seemed sufficient to justify natural astrology. The final test was: Does it work? Did the predictions prove to be true? Did the eclipse occur at the time and place expected?



An old Chinese armillary sphere, belonging, according to tradition, to the Emperor Shun, who ruled about 2250 B. C.

When we turn to judicial astrology we find that the same method of testing its truth was applied. Marvelous stories of correct predictions of mundane events may be found in the annals of astrology, for instance, Lilly's predictions of the great plague of 1665 and the London fire in 1666. One of the strangest involves Flamsteed (1646-1719), first Astronomer Royal of England, who rejected astrology. An importunate woman who had lost a valuable article made repeated appeals to the scientist to determine by the stars where to find her lost property. As a last resort to get rid of her Flamsteed sketched her house and grounds and splotched in some hurriedly invented mystical symbols, pointed to a spot and said, "Dig there." She did, and found it.

On the other hand, many false predictions are recorded. Cardan (1501-1576), an eminent mathematician and astrologer, predicted that Edward VI would live to the age of 55 years, 3 months, 17 days. The king died at the age of 16 soon after the horoscope was read. Of course an explanation of the failure was forthcoming. In a weak nativity, to insure certainty, the horoscope of every one closely related or involved was necessary. Other failures were blamed on unknown planets or other ingenious devices.

Attempting to form an unprejudiced judgment on this question, it would seem that the empirical test breaks down in the case of judicial astrology. One correct prediction outweighs a multitude of false ones. In other words, those who are predisposed to accept the truth of astrology are credulous enough to adopt the favorable cases and reject the unfavorable ones. What test or explanation may be offered? Let us detour before reaching a conclusion.

The Greeks have been credited with holding astrology in check to a great degree; but we must not forget that Ptolemy, second century A.D., the greatest scientific author of his day, in addition to writing his *Syntaxis,* also wrote his *Tetrabiblos,* the greatest text in astrology, which standardized the system that has come down to the present. We see in Ptolemy, however, a clear division of the subject and a clear recognition of the two purposes of observational data regarding the heavenly bodies, one for judicial astrology to predict human events, and the other for natural astrology for an analytical study

Ptolemy, Alexandrian astronomer and astrologer.

of the celestial bodies, the branch which has become scientific astronomy.

In the Orient, these two branches, natural and judicial, were more firmly interlocked. The Chinese astrological system is not well known in the West, so the following quotation from an early star chart may be of interest:

"Before the Great Absolute had unfolded itself, the three primal essences, Heaven, Earth and Man, were involved within. This was termed original chaos, because the intermingled essences had not yet separated. When the Great Absolute unfolded, the light and pure formed Heaven, the heavy and impure formed Earth and the mingled pure and impure formed Man. The light and pure constitute spirit, the heavy and impure constitute body, and the union of spirit and body constitute man.

"Hence all manifestations of spirit emanate from Heaven, for a natural and logical reason, being inherent in the Great Absolute. This evolves into the Sun and the Moon, divides into the five planets, arranges in order as the 28 mansions and reunites to form the directors and the circumpolar stars. All of these being involved in the immutable directing reason are also in harmony with the rational principle in Man, so they may be interpreted by reason."

That philosophical basis established the astrological system adopted for the use of the emperor of the Celestial Kingdom, which guided state action for several millenia. Astrology maintained its paramount influence in the East even later than in the West.

When Isaac Newton matriculated at Cambridge and was asked what he wished to study, he is said to have replied, "Mathematics, to test judicial astrology." What Newton found you well know—the law of gravitation, which is a physical law. Stars and planets became law-abiding members of the physical universe. No

longer were they ruled by the whim of naturalistic gods, but were subject to rationalistic principles, which may be comprehended by human reason. Natural astrology became the science of astronomy on a firm physical foundation. The so-called prediction of eclipses became the computation of eclipses. Celestial mechanics developed analytical methods to map the orbits of the celestial bodies and to determine their position and motion, not only for the present but for centuries in the past and in the future.

Jupiter was no longer ruled by Jove, so how could it impart a jovial nature? Mercury was no longer mercurial, nor Mars, martial. It is irrational to believe that these characteristics may be transmitted to the lucky or unlucky individuals who were born at an hour when the planet obeying physical law occupied a computed position in the heavens. We have reached a clear-cut distinction between natural astrology or the science of astronomy, which is founded on a firm physical basis, and judicial astrology, which remains without rational foundation. This is the real test, not the purely empirical method which breaks down in application.

Another branch, equally without foundation, was developed, known as *horary astrology,* pertaining to the hour, which answers specific questions by the position of the stars at the time the question arises. Lilly states its claim quite precisely. "If a proposition of *any nature* be made to any individual, about the result of which he is anxious, and therefore uncertain whether to accede to it or not, let him but note the hour and minute when it was *first* made, and erect a figure of the heavens, as herein taught, and his doubts will be instantly resolved. He may thus, in five minutes, learn infallibly whether the affair will succeed or not; and consequently, whether it is prudent to adopt the offer made or not." This gives the professional astrologer his best opportunity to build up a permanent clientele, who have endless questions constantly arising and consequently return frequently.

Now let us turn to contemporary astrology. On the front-page cover of a current astrological work in type more prominent than the pictorial representation of some zodiacal constellations, are the alluring topics: How to Make Money, How to Attract Love, How to Find the Right Job, How to Make Marriage a Success. Yet, as has often been pointed out, astrologers as a class are no richer, no more successful in love, no wiser and no happier than other folks. Perhaps they don't profit by taking their own medicine.

Here is a quotation from a current magazine. "Whatever your problems—love, money, marriage, business, health, vocation, child training, locational, investing, hiring, firing, finding employment, starting in business, making changes,—in short, any and all problems of this life, scientific astrology can help you to the successful solution."

We are told in a current astrological magazine (*Horoscope,* September, 1941) that Mars retrogrades this year, September 6th to November 10th, from 24° Aries to 11° Aries. We consult the computed position of Mars published three years in advance in the *American Ephemeris and Nautical Almanac* and we find that it will be in the constellation Pisces, not Aries, during that time. I am willing to stake my reputation as an astronomer that the computed position is correct.

Of course, you know the reason for the discrepancy. Astrologers are still using the signs of the zodiac according to their position 2,000 years ago. At that time the vernal equinox corresponded to the First of Aries; but due to precession the equinox has moved backward about 30 degrees and is now in the constellation Pisces. A similar discrepancy holds for all the signs, so not one of them occupies the position of the constellation whose name (and influence, if any) it bears.

Here is another quotation from a current magazine. "Astronomers announced some years ago that there was an observable difference between the spectrum of Mars when he was retrograde, and the spectrum when he was direct. . . . The Sun's light reflected from Mars thus reveals, when broken up by the spectroscope, the physical components of the planet. Insofar as these rays are the cause of the planet's astrological influence on men, the differences between the spectra of the retrograde Mars and the direct Mars is an important scientific confirmation of a truth that Astrology has been aware of for a long time: namely, that the influence of a planet changes noticeably when it is retrograde." What are here designated as the "physical components" revealed by the spectroscope do not change one iota when the apparent motion is retrograde, nor does the spectrum of the planet. Mars continually revolves eastward about the sun obeying Kepler's laws and "the Sun's light reflected from Mars" cannot possibly be changed by the apparent retrograde motion. Ignorance on the part of the author is a poor excuse for attempting to appear scientific and for using an erroneous statement, which he attributes to astronomers, in an effort to bolster up his unscientific doctrine.

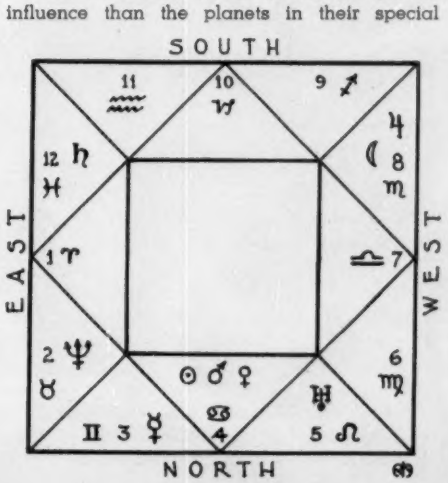
Let us bring the claims of astrology into closer contact with the philosophy of life of the average American. Again I quote from astrology: "The exact day, month and year of your birth, according to experts, definitely decides the outcome of your plans, efforts and hopes. Centuries of study prove that predictions made on the basis of the exact day a man or woman is born have come amazingly true." That doctrine might accord with medieval Calvinistic predestination by which the fate of men and women are predetermined by divine decree, but the possession of free will repudiates the doctrine. I do not believe that my fate was sealed on the day I was born. I am the captain of my soul. America is the land of opportunity, and every child born here has a right to aspire to a successful career of his own choice and making. Americans know no unlucky stars; all are born under the lucky Stars and Stripes.

The Horoscope of W. Carl Rufus

Chiefly according to Lilly

BIRTH, about midnight, June 30-July 1, 1876. The positions of the heavenly bodies were obtained from the **American Ephemeris** for that year. The sun was in Cancer, the fourth sign, and it falls in the fourth house. Thus all the signs of the zodiac fall in houses of corresponding number—a very fortunate nativity.

Aries, in house 1, the **ascendant,** has greater influence than the planets in their special houses and controls the most important issues of life.



We will begin, however, with the planets in their respective houses. The most powerful houses are the so-called **angles,** nos. 1, 4, 7 and 10. Houses 1, 7 and 10 are vacant. In 4 are the sun, Mars, and Venus, a very remarkable combination. Next in order of influence are the **cusps,** houses 2, 5, 8 and 11. In 2 and 5 are Neptune and Uranus respectively, two planets discovered too late for great influence in early astrology. In house 8, however, is Jupiter, one of the two most important **benefics,** the other being Venus. In 8 is also found the moon, which reflects and reinforces the good fortune due to Jupiter. The weakest houses are the **cadents,** houses 3, 6, 9 and 12. In 3 is Mercury and in 12 is Saturn. Mercury is questionable, but Saturn is one of the greatest **malefics,** the others being Mars and Uranus.

Let us begin with the planets of weakest influence and consider them in the houses occupied. Mercury, the swift planet, gives a disposition quick-tempered, liable to change, fickle, inconstant. In Gemini other characteristics are added: tall, upright, straight body, well-formed, very intelligent looking; ingenious

imagination, good speaker, cunning, clever; one who perfectly understands his own interests, a subtle politician, not easily deluded by the most cunning knave he may encounter.

Saturn, the great **infortune,** is in a cadent; consequently its influence is not as great as it would be in a cusp or an angle. Saturn in Pisces gives a character active to do mischief, malicious, given to contention and dissimulation, an uncertain, fickle person, though often presenting a good exterior, yet fraudulent and deceitful in the end. Not loquacious, but deliberate, doing evil with malice aforethought. They are said to improve with age (a chance for me).

Next let us take house 8 of intermediate influence. Jupiter in Scorpio gives a medium stature, stout, compact body; dark, coarse hair, fleshy and full face; muddy, dull complexion. Manners, proud and lofty; one who is ambitious, desires to overrule his equals, resolute, covetous, ill-natured and selfish; very subtle and crafty, therefore to be very warily dealt with.

The moon in Scorpio gives a thick, short, ill-shaped person; with a character sottish and vulgar, malicious, brutish and treacherous. It also reflects and reinforces the influence of Jupiter just described.

Now let us take the angle, the house of greatest influence, number 4. What a combination, the sun, Venus and Mars! The sun in Cancer gives a harmless, cheerful person, but indolent, not fond of employment, one who spends his time in sports and pastimes, dancing, etc., and is greatly addicted to women.

Venus in Cancer. The disposition is idle and dull, fond of low company, and vicious pleasures and pursuits. Very fickle and timid, puts the best side outwards, seems to be in earnest when he is not, ever mutable and inconstant.

Mars in Cancer. (A climax.) The temper is sour and bad, one given to sottishness; a mean, servile, unfortunate creature; usually employed in some low business, being incapable of better.

Probably a $1.00 reading would leave the horoscope at this point. But I have too much at stake to stop here.

As previously suggested, when the signs fall in the houses with corresponding numbers, the subject should be very fortunate. Also Aries in the ascendant has greater influence than the planets. In that position it signifies strong passions and positive characteristics. This is strongly supported by the regular influence of the sun in Cancer, which signifies a nativity positive in disposition, optimistic, a good manager. Dominant in devotion and family life. Ardent as lover or husband. Conjugal with Taurus, Gemini, Aries, Scorpio, Sagittarius and Libra. Please note here that Mrs. Rufus was born under Scorpio, hence our long and successful married life, nearly 40 years.

The **consignificators** of the fourth house are Cancer and the sun, both of which occupy that house, which rules the breast, the heart and the lungs, and gives judgment to fathers. Of significance also is the fact that this house in the north is the angle of the earth. The consignificators indicate the strong influence from that direction.

The character derived from the sun is very faithful, keeps promises with greatest punctuality, has a desire to persuade and rule. Prudent, incomparable judgment; great majesty and stateliness, industrious to acquire honor and a large patrimony, yet willing to spend it again. Speaks with gravity, not given to many words, but with great confidence and

Prof. and Mrs. W. Carl Rufus in the Chinese moon gate at the entrance to their informal Oriental garden.

self-control, full of thought, secret, trusty, deliberate, affable, tractable, very humane to all people; loving magnificence and honor—no sordid thoughts can enter his heart.

Furthermore, Jupiter, the greatest benefic, is the consignificator of the eighth house and we find him also at home giving a character which is magnanimous, faithful, bashful, aspiring to high goals, lover of fair dealing, helpful to all, performing glorious deeds, honorable and religious, sweet and affable in conversation, indulgent to wife and children, reverencing age, reliever of the poor, full of charity and godliness, liberal, hating all sordid actions, just, wise, prudent, grateful and virtuous. When you find Jupiter the significator of any man you may judge him accordingly.

And in addition the moon reflects all this glory. The nearer the moon is to a planet the greater is the reflected influence. Here is another climax, the moon and Jupiter were in conjunction on the very day of my birth!

Mercury is the star of astrologers, philosophers, mathematicians, statesmen, travelers, intellectuals and artists. When well dignifed (here it is not **combust** but is quite distant from the sun) Mercury represents a man of a subtle and political brain and intellect; an excellent disputant or logician, arguing with learning and discretion, and using much eloquence in his speech; a searcher into all kinds of mysteries and learning, sharp and witty, learning almost anything without a teacher; ambitious of being exquisite in every science, desirous naturally to travel and see foreign ports (we have been around the world three times and have visited 50 foreign countries), a man of an unwearied fancy, curious in the search of any occult knowledge, able by his own genius to produce wonders, given to divination and the more secret knowledge. (Due credit is here given to the source of my ability as a horoscoper.)

The **aspects** of the planets should be considered to find out their mutual effects; occasionally good influences are annulled or evil influences are introduced by these relationships. We have already called attention to the highly beneficial effects of conjunctions and of consignificators occupying their own houses.

Oppositions in general weaken the influences. The most powerful group in house 4 has no planets in opposition in house 10. The next powerful combination in house 8 has only Neptune in opposition. Saturn, the unlucky star in house 12, is opposed by Uranus, which is likely to act suddenly and unexpectedly against the weak, evil influence of Saturn in a cadent house. **Trine,** or the 120° relationship, has a good effect. So all the good influences of houses 4 and 8 are strengthened. These relationships combine to make this horoscope an excellent example of those fortunate influences which completely overcome the evil effects of the individual planets. We conclude with a nativity enjoying all the beneficial effects that could be found during this brief excursion in the uncertain realm of unscientific astrology.

LATE PHOTOS FROM MANILA

(Reproduced on facing page)

November 24, 1941

THESE pictures come to you when the occultation of Mars on November 1st is past history. Yet, because it happened in our part of the world—and **your** part was not similarly blessed—the pictures may be of some interest to your readers.

We had fairly good seeing on the day of the occultation. The closeness of the planet to the moon many hours after sunset, and the disappearance behind the dark limb, caused no little curiosity and excitement among those not too busy at the time to look up at the heavens.

The times for the two pictures are: an hour before immersion, and halfway during the immersion, at 22h 18m 23.6s, Manila Time. The images were magnified in our 19-inch equatorial refractor, 7-meter focal length. Panchromatic cut film was used. As you see, the extra-focal image of the moon was too big for the plate. The rest of the moon was sacrificed in order to bring Mars clearly into the picture as some kind of identifiable disk. The second picture shows Mars half "swallowed" in the dark limb of the moon. These pictures have not been published elsewhere. You may use them in any manner you think best.

While the pictures were being taken, Father Leo W. Welch, S.J., took charge of timing the contacts, and his results are as follows (Manila Standard Time):

First contact 22h 17m 58.8s
Second contact 22h 18m 51.3s
(both observations made at the 4-inch finder of the equatorial);
Last contact at emersion..... 23h 55m 50s
(with a "Monoctar" glass).

Congratulations for your splendid SKY, especially for your careful reproductions of the illustrations, and your choice of popular articles. The new **Sky and Telescope** will be, I am sure, a happy combination, and will bring your publication to a wider reading public.

Very faithfully yours,

PABLO GUZMAN-RIVAS, S.J.
Staff member, Manila Observatory

EDITOR'S NOTE: This letter was received on December 8th, the day after the outbreak of hostilities between the United States and Japan. It came via Clipper, postmarked at Manila November 29th.

NEWS NOTES

By Dorrit Hoffleit

REFUELING THE STARS

What keeps the stars shining? Within the last few years astronomers have answered this question by saying it is the transmutation of hydrogen into helium by means of the carbon cycle, a process which releases radiant energy. But suppose a star uses up its supply of hydrogen? Drs. R. A. Lyttleton and F. Hoyle, of Cambridge University, England, have studied the problem and find that the average star's hydrogen supply is inadequate to keep it shining unless it can acquire more hydrogen from the outside.

The space between the stars contains about as much matter as the stars themselves. Although a large proportion of this interstellar matter is calcium and sodium, some hydrogen molecules have been detected. According to the Cambridge scientists, the sun sweeps up some 110,000 tons of hydrogen every second as it rushes through space, and it and the other stars can find all the fuel they need.

POPULAR LECTURES AT SWARTHMORE

A series of popular astronomical lectures is being given at Swarthmore College under the auspices of the department of mathematics and astronomy and the William J. Cooper Foundation. The program of the remaining lectures is as follows:

January 8, 8:15 p.m.—**Our Sun,** by Martin Schwarzschild, Rutherfurd Observatory, Columbia University.

January 13, 4:15 p.m.—**Our Cosmical Neighbors,** by Armstrong Thomas, Sproul Observatory, Swarthmore.

January 15, 8:15 p.m.—**Cosmic Rays,** by W. F. G. Swann, director, Bartol Research Foundation, Swarthmore.

January 20, 4:15 p.m.—**The Moving Stars,** by Peter van de Kamp, director, Sproul Observatory.

January 22, 8:15 p.m.—**Our Milky Way,** by Dr. van de Kamp.

VATICAN AWARDS PRIZE

On November 30th, news was received that Dr. Harlow Shapley, director of Harvard College Observatory, had been awarded the Pope Pius XI prize of the Pontifical Academy of Science, amounting to 50,000 lire (approximately $2,500) for his nebular researches. The award was announced by the president of the academy, the Rev. Agostino Gemelli, at a meeting attended by Pope Pius XII.

PULKOVO OBSERVATORY

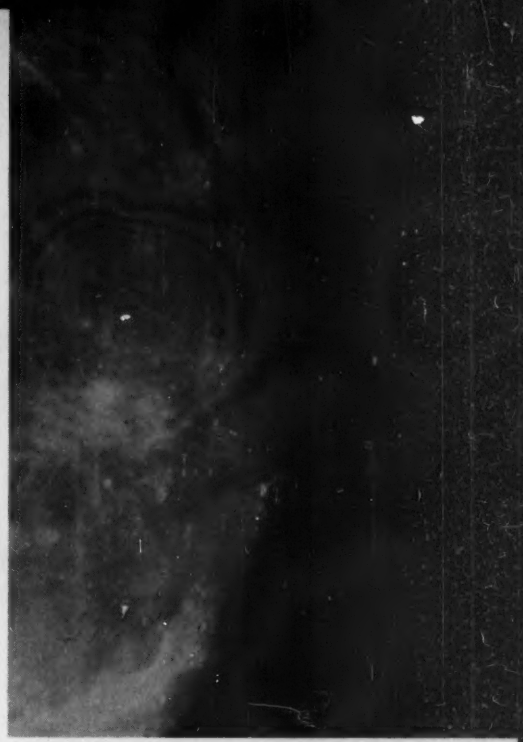
The destruction of Pulkovo Observatory, situated near Leningrad, has recently been reported (see Astronomical Anecdotes). Besides numerous instruments, including a 30-inch Alvan Clark refractor, the observatory had a valuable collection of Kepler manuscripts.

Through the work of the Struves, Belopolsky, and others, the observatory distinguished itself in many ways, giving astronomers a heritage of catalogues and contributions on star positions, double stars, spectroscopy, and other branches of astronomy. At the time of its erection, the Pulkovo 15-inch was the largest refracting telescope in the world. The instrument, constructed by the successors of Fraunhofer in Munich, was of such excellence that Harvard College, in establishing its own observatory nearly 100 years ago, ordered an exact replica.

"FUNDAMENTAL PROPERTIES OF THE GALACTIC SYSTEM"

The New York Academy of Science announces the publication of this volume, composed of papers by Bart J. Bok, Dirk Brouwer, W. J. Luyten, D. A. MacRae, H. R. Morgan, Jan Schilt, F. H. Seares, P. van de Kamp, and Emma T. R. Williams. The price is $1.75, and orders should be sent to the Academy at 79th St. and Central Park West, New York.

Mars, an hour before immersion, November 1st. Both engravings on this page are of the same scale as the original photographs taken with the 19-inch refractor of the Manila Observatory. (See letter opposite.)



OCCULTATION OF MARS

This remarkable photograph from Manila shows Mars half covered by the dark limb of the moon during the occultation of November 1st. It is difficult to realize that the actual edge of the moon extends so far beyond the terminator.

HUBBLE SPEAKS AT DALLAS

Dr. Edwin Hubble, of Mt. Wilson Observatory, addressed the 42nd annual convention of the Society of Sigma Xi and the A.A.A.S., December 30th. His subject was "The Expanding Universe Theory."

SOUTH AMERICAN INTEREST IN ASTRONOMY

In April, the first astronomical fair in South America was held in Buenos Aires under the sponsorship of the Asociacion Argentina "Amigos de la Astronomia." The opening was a grand affair attended by the vice-president of Argentina and other government officials. An article in the **Revista Astronomica** for May and June, just received, describes the exhibits and gives a 7-page list of the instruments, photographs, and models displayed. It is evident that South American amateurs and telescope makers are keenly and actively interested in their hobby.

ROYAL SOCIETY MEDAL

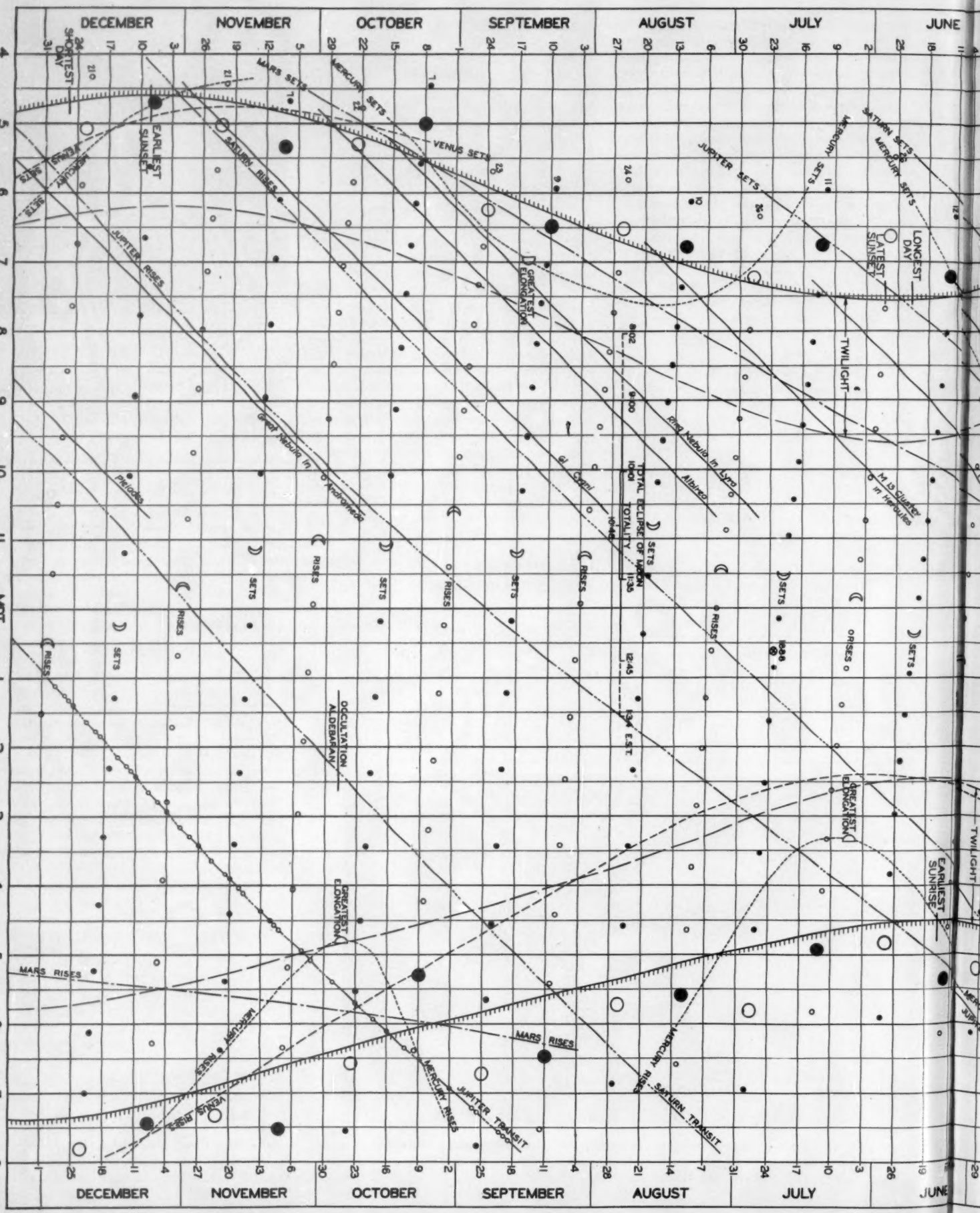
Science reports that the King of England has approved the recommendations of the Council of the Royal Society awarding a royal medal to Prof. Edward Arthur Milne, of Oxford, "for his researches on the atmospheres of the earth and sun, on the internal constitution of the stars, and on the theory of relativity."

NEWS NOTE CORRECTION

In the December, 1941, issue, page 6, column 1, line 19, for "Schlesinger and Alden," read "Schlesinger and Alter."

Graphic Time Table

PREPARED BY THE MARYA



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The Heavens = = 1942

Academy of Sciences

Instructions for Use of the Chart

The Graphic Time Table of the Heavens gives the rising and setting times of the sun, moon, and planets; the beginning of morning twilight and the ending of evening twilight; the times when certain stars and other objects of particular interest cross the meridian (that imaginary line which splits the sky into its eastern and western halves); the phases of the moon, and other interesting astronomical information. To illustrate by an example: the events of the night of January 8th may be found by following the horizontal line for that date across the page from left to right. We find that the sun sets at 4:50 p.m.; the planet Mercury sets at 5:37; evening twilight ends at 6:28; Venus sets at 7:38; the planet Saturn transits (crosses the meridian) at 8:08. Then the Pleiades transit at 8:34, followed by Jupiter at 9:32, and the Great Nebula in Orion at 10:22. The moon rises at 11:10; Mars sets at 1:17 a.m., January 9th, followed by Saturn at 3:07, and Jupiter at 4:53. Morning twilight begins at 5:45, and the sun rises at 7:22, concluding a night 14 hours, 32 minutes long.

The dashes on the sunrise and sunset curves are for interpolation on other days besides those marked by the horizontal lines.

The phases of the moon are indicated by the conventional signs, as follows: the large, solid black circles indicate new moon; the crescents with horns pointing left mean first-quarter moon; the large open circles mean full moon; and the crescents with horns pointing right, last quarter. Thus the moon will be full on January 2nd, on which date it rises at 5:12 p.m., and will reach last quarter on January 9th, rising 13 minutes past midnight. The small black circles show moonset for the first half of the lunar month, and the small white circles show moonrise from full to new moon, the second half of the lunar month. Further features of the Graphic Time Table are described on the next page.

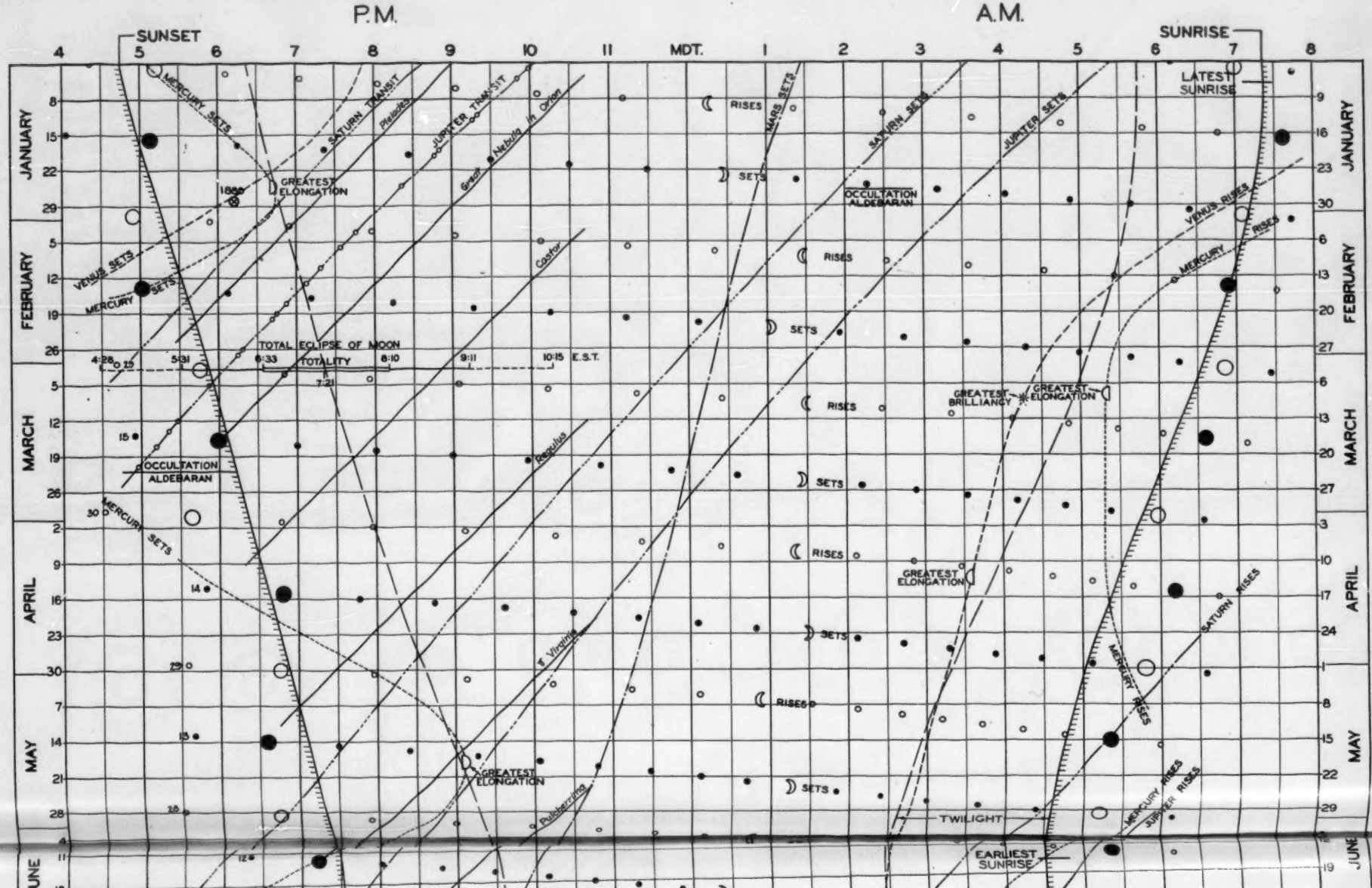
How to Correct for Your Position

As in all almanacs, the times of rising and setting of the sun, moon, and planets are absolutely correct only for one particular point on the earth's surface, in this case latitude 40° north, longitude 75° west, and Eastern Standard Time. However, wherever he is, the observer may easily correct the Graphic Time Table for his position. Correction for difference of latitude is comparatively minor and may in general be neglected since the members of the solar system for which the times of rising and setting are given are never very far from the celestial equator. It need only be remembered that when these bodies are north of the equator, as will generally be the case of objects seen at night during the winter months, they remain visible longer as we go farther north, and for lesser time in lower latitudes.

Correction for difference of longitude depends only upon the distance the observer is east or west of his own particular standard time meridian, as shown in the following table:

	Minutes		Minutes		Minutes
Atlanta	+38	Detroit	+32	New York	— 4
Baltimore	+ 6	Helena	+28	Philadelphia	+ 1
Boston	—16	Houston	+22	Pittsburgh	+20
Chicago	—10	Los Angeles	— 7	San Fr'cisco	+10
Cincinnati	+38	Minneapolis	+13	St. Louis	+ 1
Denver	0	New Orleans	0	Washington	+ 8

All places with plus correction are west of the standard meridian and therefore these events occur later. The usual correction of one hour for standard time zones must be made to times for eclipses of the moon and "transits" of Jupiter's satellites. Slight corrections must also be made to times of moonrise and moonset in the far west. For times of occultations and solar eclipses refer to the **American Ephemeris.**



Graphic Portrayal of Celestial Events

By Carroll F. Merriam

IN the center pages of this issue of *Sky and Telescope* is a facsimile reproduction of the Graphic Time Table of the Heavens for 1942, issued annually by the Maryland Academy of Sciences in Baltimore, Md. This is accompanied by directions for the use of this chart, but there are many special features of interest to the amateur and to the student of astronomy, so it seems fitting to call them particularly to the attention of the readers of *Sky and Telescope* through these columns. A careful study of the graphic portrayals of common phenomena on the chart will give the lover of astronomy much to think about.

The most noticeable of these is the annual variation in the length of the day, or, perhaps better, the night, for the chart is much more concerned with the hours of darkness than with those of daylight. The narrowing of the sunrise and sunset curves in the middle of the year shows how much difference there is at the 40th parallel of latitude, for which this chart was computed. More than that, the somewhat surprising length of time between the day of earliest sunset and the latest sunrise is brought out. The day grows longer after the winter solstice by the sun setting later rather than by its rising earlier, and on the chart this is nicely illustrated. At this season the rapid change in the equation of time, the real sun speeding ahead of the mean sun, is sufficient to offset the sun's decreasing declination, beginning early in December, so the earliest sunset comes some time before the sun reaches the Tropic of Capricorn.

To a lesser extent the same is true near the summer solstice, but at this time the rate at which the real sun gains is not so great. Consequently, the days of earliest sunrise and latest sunset are not displaced as much.

The length of twilight, too, exhibits changes with the seasons, and it will be observed how much wider the band is near the end of June than any other time of the year. We have all enjoyed the long summer twilights, but have not found it easy to compare their length with that of other seasons.

Had the chart been drawn for a more northern latitude, the contraction in the center would be even more pronounced, and for latitude 48½ degrees the two twilight curves would join each other. Still farther north there are nights in midsummer when the sun never sinks more than 18 degrees below the northern horizon, which is then continually tinged with the faint traces of the merged twilight and dawn.

In the northern hemisphere, the best time to see Mercury as an evening star is in the spring, and as a morning star in the fall, as is shown by comparing the twilight curves with the rising and setting of this elusive planet. Furthermore, it is easy to pick out the six opportunities for best observing Mercury in each year, when it is at greatest elongation.

The moon shows interesting variations from season to season, as demonstrated by the unequal spacing of the points marking the times of rising and setting. This crowding, which signifies less than average difference in the rising time from night to night, is more pronounced near daybreak at the end of March, around midnight at the end of June, and around sunset in the fall. When this crowding comes in the fall of the year, and the full moon rises not far from the same time for several nights in succession—a phenomenon that is much more pronounced in more northern latitudes—it is called the harvest moon. Near the Arctic Circle the moon may actually rise earlier on the second night than on the first, but not this year.

Another curious result of the inclination of the moon's orbit, relative to the plane of the ecliptic and the shifting position of the nodes, is that when the moon starts to occult a star like Aldebaran, which is very nearly five degrees from the ecliptic, these occultations follow month after month for a considerable period. Last year there were five occultations of Aldebaran visible from Washington, and this year there are three. Soon, however, the moon will give up this habit and be cured for a long time. Other stars, like Regulus, get over being occulted very quickly, but have two spells at almost equal intervals in 18 years.

It is interesting to look over an *Ephemeris* for 1888, and find a striking resemblance to the eclipses of this coming year. There were in that year two total eclipses of the moon which were visible in the United States; the solar eclipses were only partial and visible in polar regions just as those this year. Suppose we count the number of days from January 28, 1888, to March 2, 1942; we find that they total 19,756. And in addition, the middle of the eclipse comes just about the same time of day. If we do the same for the second of these eclipses, July 23, 1888, and August 25, 1942, we find likewise that they are spaced exactly 19,756 days apart. Does that suggest to you how the ancients, with little means of making astronomical calculations, were able to predict eclipses rather accurately?

The times of circumstances of the eclipses of the moon are shown in Eastern Standard Time, and are: entering the penumbra, entering the umbra, beginning of totality, middle of eclipse, end of totality, leaving the umbra, and leaving the penumbra, in that order.

The planetary configurations can be judged fairly closely by the times of rising and setting. When two objects, such as the moon and Jupiter, set approximately at the same time, as they do on February 23rd, it stands to reason that they are at least close to each other in the heavens and should be in conjunction within 12 hours. The fact that Mars is in conjunction, first with Saturn about the middle of February, and again with Jupiter at the end of March, is plainly seen from the way that Mars' setting curve crosses those for the other two planets. Likewise, when a planet rises at sunset, it must be near opposition, but not necessarily just at opposition. And it will be seen that from January 27th to February 4th Venus sets after the sun and rises before dawn, thus apparently playing the part of evening and morning star at the same time.

The curve labelled *Jupiter Transit* has small circles on it. These are designed to call attention to disappearances of the satellites of Jupiter behind the planet or its shadow, such events being selected as occurring between the hours of seven and ten in the evening (E. S. T.).

And so to the lover of astronomy this single sheet, with its seeming tangle of lines and curves, is more than a mere condensed almanac. With patience the careful observer can find on it lots of little things to sit and ponder over. The men who have composed it hope they may pass along to others their pleasure in following the changes that occur from year to year.

While still available, copies of the Graphic Time Table of the Heavens for 1942 may be secured without charge directly from the Maryland Academy of Sciences, 2724 N. Charles St., Baltimore, Md., by readers of **Sky and Telescope** and their friends, and by teachers of astronomy for their classes. The latter may be interested in securing blueprints of the original before reproduction, size 40 by 27 inches, at cost of printing.

The Planetarium

Black, twin-headed, magic monster,
In courtly high-vaulted cave,
With your hundred flashing eyes
Spangle the darkness
And show me the midnight skies.
Here, where clouds are spun
But to enhance the moon
And hold the colors of the dawn,
Time and tide for once do falter
And wait upon the wish of him
Who holds the monster's halter.
Here we mortals are allowed to hear
The music of the spheres,
Heralding our blessed sight
To watch the rare unfolding
Of a common thing—celestial night.

Dante Vezzoli

BEGINNER'S PAGE

By Percy W. Witherell

Saturn and Its Rings

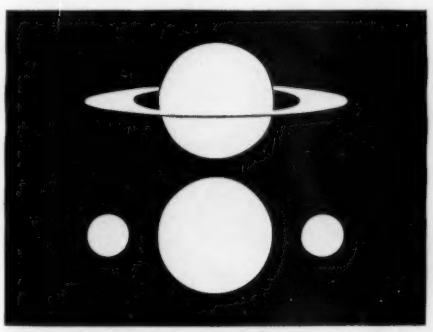
SATURN, the wonder planet (see back cover), is now favorably situated for observation in the southeast evening sky in Taurus, near the Pleiades. Known to the ancients as one of the wandering stars, it remained for Galileo with his plano-convex and plano-concave telescope to discover in 1610 that Saturn was not of a simple form as commonly supposed. But his crude instrument showed only a peculiar triple form (below), and it was not until 1655 that Huygens demonstrated the form of the ring. Then in 1675, Cassini discovered that the ring was double. In 1850, Bond of Harvard revealed the presence of a third inner dusky gauze ring, so thin that the body of the planet and its satellites were sometimes visible through it. Later, Encke showed fine dark divisions appeared under favorable seeing conditions in the outer ring, and Lowell observed a division 1,000 miles wide between the middle bright and the crape rings.

One of the remarkable features of these rings is their extreme thinness, as very clearly shown at 15-year intervals when their relative position to the earth places them edge-on to us. At these times they are invisible for a few days even in large telescopes, and appear as only a fine line before and after the critical days.

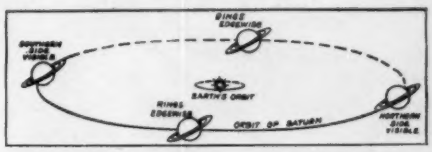
Although the outer ring is 171,000 miles in diameter, it is less than 10 miles in thickness.

The spectroscope, the magic wand of modern astronomy, shows that the inner parts of the rings rotate more rapidly than the outer, and celestial dynamics demonstrates mathematically that the rings are composed of small rocks surrounded by fine dust particles.

Saturn appears yellowish-white in the equatorial regions and greenish-blue at the poles, with the edges slightly darker than the center. Its surface markings are so ill-defined that its period of rotation is not certain, but Barnard gives 10 hours and 38 minutes as the period in latitude 36° north in 1903.



The upper drawing shows the aspect of Saturn in 1610, and the lower is Galileo's representation of what he saw—a triple planet. His telescope was strong enough to show the broad extremities of the ring ellipse, but not the narrow parts near the planet. From *Splendour of the Heavens*.



The diagram above shows how the rings of Saturn appear turned at different angles to earth observers, although *they maintain their inclination of 27* degrees to the ecliptic. From Baker's *Astronomy*.

Therefore at intervals of 15 years, Saturn's rings appear alternately opened out and edgewise (right), causing the apparent brightness of the planet to vary considerably. Drawing by Proctor.

The equatorial diameter is 74,100 miles and the polar diameter 66,300 miles. It is the most flattened of the planets with an oblateness of 9.5 per cent. The equator is inclined 26° 45′ to the plane of its orbit, and its orbit 2°.5 to the ecliptic.

At a mean distance of 887 million miles from the sun, with a variation of 100 million miles on account of the eccentricity of its orbit, Saturn takes 29.5 years to go around the sun, so that its apparent position in the sky changes very little each year.

Its brightness varies as much as 70 per cent, due to the relative position of its rings toward the earth (right) and the variation in its distance from us (745,000,000 to 1,027,000,000 miles).

Satellites to the number of nine were discovered between 1655, when Titan was found by Huygens, and 1898, when Pickering noticed tiny Phoebe with its retrograde revolution. Bond discovered the eighth satellite at Harvard in 1848. In 1905, Pickering announced the discovery of a tenth but it has not been confirmed as yet. It is thought that the satellites keep the same side toward the planet. As Iapetus varies five times in brightness during its rotation around the planet, its two sides must be very different.

Although Saturn's mean diameter of 71,500 miles places it near Jupiter in bulk, its very low density (0.715 times that of water) makes its composition of great interest.

Rupert Wildt believes that the inner core of rock and iron of 28,000 miles diameter is surrounded by ice 6,000 miles thick, about which is an atmosphere 16,000 miles deep. This atmosphere is gaseous for only a few hundred miles at the top and the rest is liquid or solid methane (marsh gas) and ammonia. The weight of the atmosphere is about the same as the core.

A globe 22.5 inches in diameter, surrounded by a ring of the thickness of the paper in this magazine, placed at a distance of 2 inches from the surface, 12½ inches wide, with an outside diameter of 51½ inches, would be a model of the system. The nearest satellite would be in an orbit 35 inches from the center of the globe and the outer satellite 200 feet from the center. The sun might be represented by a globe 23 feet in diameter at a distance of four miles.

THE RINGS

	Width in mi.
Outer Ring A	10,000*
Cassini division	3,000
Middle Ring B	16,000
Lowell division	1,000
Crape Ring C	11,500
Space to planet	7,500

*With Encke division.

THE SATELLITES OF SATURN

	Satellite	*Discoverer*	*Year*	*Mean distance miles*	*Sidereal period d. h. m.*	*Diameter miles*	*Stellar mag.*
7	Mimas	W. Herschel	1789	115,300	22 37	400	12.1
6	Enceladus	W. Herschel	1789	147,800	1 8 53	500	11.6
5	Tethys	Cassini	1684	183,000	1 21 18	700	10.5
4	Dione	Cassini	1684	234,400	2 17 41	700	10.7
2	Rhea	Cassini	1684	327,300	4 12 25	1100	10.0
1	Titan	Huygens	1655	758,800	15 22 41	2600	8.3
8	Hyperion	G. P. Bond	1848	919,700	21 6 38	300	13.0
3	Iapetus	Cassini	1671	2,210,000	79 7 56	1000	11
9	Phoebe	W. Pickering	1898	8,034,000	550 10 33	150	14.5

Amateur Astronomers

MIDWESTERN AMATEUR'S OBSERVATORY

By Jack Sundine—*Northwestern University*

TO provide facilities for people in his community to learn about astronomy, amateur astronomer Carl H. Gamble has recently completed a small observatory near his home southeast of Moline, Ill., on Coaltown Road. The observatory, named Sky Ridge, is situated on a high bluff overlooking the Rock River valley, with a wide horizon to the east, south, and west, and "a fairly good horizon to the north."

Mr. Gamble, who is known in the region as a leading amateur astronomer, states that he built the observatory to further work on his hobby and to serve the community. Dates will be set aside each month during the season when the sky is clear for observing by the public.

Fifty yards from his newly built home, Mr. Gamble's observatory is a two-room building, 18 by 28 feet, with the revolving observation dome on top surrounded by an open-air deck 22 by 32 feet. In the larger of the two rooms is the amateur's science library and lecture room. Furnished with stove, desk and telephone, this room serves as his hobby office.

The dome is 16 feet, 8 inches, in diameter, and is in reality the top of a standard-type silo, which engineers from John Deere Spreader Works, where Mr. Gamble is manager, helped him install. They also aided in the construction of the slot in the side of the dome. This is made of corrugated galvanized sheet steel inserted crosswise and attached to an endless chain, with which the slot is opened and closed by hand pulleys inside the dome. Mr. Gamble hopes to install electric power.

Sky Ridge Observatory has an observing platform from which visitors may study the constellations while awaiting their turns at the telescope.

The telescope is a Carl Zeiss 5½-inch refractor with a mounting by Alvan Clark and Sons. The cast-iron pier is set in concrete in the ground one story below and is independent of the dome flooring. This is the usual way to prevent vibration caused by people walking on the floor. An electric slow-motion drive in right ascension compensates for the earth's motion and keeps the telescope pointed at the object being observed.

Included in the accessories for the telescope are a triple revolving eyepiece-holder, a solar diagonal to observe the sun, a zenith prism, an erecting prism, and a binocular attachment for terrestrial observations. Eyepieces range from 40 power to 380 power.

During the past decade Mr. Gamble has given formal talks on popular astronomy to 222 groups, comprising more than 20,000 persons. As well as furnishing the headquarters for the Moline Popular Astronomy Club's monthly meetings, Mr. Gamble encourages any individual or group to visit him at Sky Ridge, where he tells interesting stories about the stars while his guests look through his telescope. He recently gave a lecture on current affairs to members of the high school civics club, after which he invited them out to Sky Ridge to see the "parade of planets." Out-of-town visitors are always welcome, the amateur says.

Mr. Gamble avoids technical information in presenting astronomical facts to a general audience. He is not a research astronomer, he says, but merely a student. "I want as many people as possible to have a general knowledge of astronomy. When they do, many superstitious fears can be forgotten, for knowledge dispels superstition."

Report of Progress—A.A.L.A.

THREE more societies have tentatively ratified the proposed by-laws of the Amateur Astronomers League of America. The first is the Amateur Astronomers Association of New York, whose Board of Directors has agreed, subject to the approval of the membership of the society, to join the League, provided certain changes are made in drawing up the final by-laws. The second is the Amateur Astronomers Association of Pittsburgh, whose members ratified membership in the League on November 14th, although the report of a committee on the by-laws was not finally voted on until the meeting of December 12th, when League membership was made subject to somewhat similar conditions to those proposed by the New York society.

The third is the Popular Astronomy Club of the Tri-Cities, which sent word of ratification as this report went to press.

The following groups reported that the by-laws were to be under consideration at meetings during December and January, so it is expected that definite word from many of them will be received shortly.

Astronomical Society of Maine
Burnham Astronomical Society
Eastbay Astronomical Association
Indiana Astronomical Society
Milwaukee Astronomical Society

In order that other groups may be guided by the most important of the changes proposed, they are briefly listed herewith.

1. That the annual dues do not exceed $1.50 per individual member of each organization. (Original provision is for $2.)
2. That the A.A.L.A. be incorporated. (It was proposed at the Washington Convention that this be done by Act of Congress.)
3. That there be an audit of the League's books, published annually.
4. That the reference to astrology in the preamble be omitted and a line inserted in the body of the by-laws providing for the same spirit of active force against all pseudo-sciences.
5. That withdrawal of an organization be permitted on 60 days' notice.
6. That amendments to the by-laws be voted on according to a society's representation at a national convention.
7. That Article I, Section 3, be reworded so as to exclude any individual member whose dues are less than those paid by a society's regular members and who by virtue of a special class of membership in such organization is not entitled to full privileges therein.
8. That the liability of an organization for the League's debts shall not exceed the dues and initiation fees prescribed for that organization in the by-laws.
9. That dues be paid in monthly instalments.

Societies which are considering the proposed by-laws may have specific problems to which the above proposals relate. Such groups may wish to ratify the proposed by-laws subject to similar conditions, all of which will be acted upon by the first temporary council, as provided in the proposed by-laws. It is understood, however, that in publishing the above proposals, it is for the purpose of assisting other groups in the manner suggested, and that such groups are under no obligation to accept or reject them at the present time.

Reprints of the proposed by-laws are still available in any quantity.

CHARLES A. FEDERER, JR.
Chairman, Comm. on Perm. Org.
Harvard College Observatory

December 16, 1941.

AMATEUR ASTRONOMERS ASSOCIATION
New York City

The meeting of January 7th will be devoted to a Symposium on **The Sun and the Earth,** conducted by society members. The chairman will be Dr. Clement S. Brainin, president of the A.A.A. Subjects covered will include the importance of solar study; atmospheric phenomena; climate and the weather as related to the sun; solar corona, atmosphere, surface; sunspots; the source of solar energy; and the practical utilization of solar radiation.

On January 21st, Dr. Benjamin Boss, of the Dudley Observatory, Albany, N. Y., will talk on **The General Catalogue,** and the human interest story behind the making of the famous work.

ASTRONOMY IN FLORIDA

Amateurs traveling to the South may want to attend some of the meetings of the Daytona Beach Stargazers, which are held every other Monday. This is the group with which William Tyler Olcott was so closely associated. Interesting programs are scheduled for the coming months:

Jan. 5—**Time**—William Ronald
Taurus—Mrs. Wm. T. Thomas
Jan. 19—**Space**—Dr. Evans B. Wood
Orion—Mrs. Wm. Ronald
Feb. 2—**Matter**—F. Beacom Rich
Leo—J. O. Codding
Feb. 16—Visiting speaker (open)
Perseus—Katherine Masters
Mar. 2—**The Seasons**—Mrs. Wm. Ronald
Lyra & Cygnus—Mrs. E. Lichty
Mar. 16—**Famous Visitors from Space**—R. E. Stevens
Sagittarius & Scorpius—Leah Watters
Mar. 30—**Air Navigation**—W. T. Thomas
Hercules—George Brannack

See Here and There with Amateurs on page 27 if you plan to travel this winter and want to visit fellow amateurs in other parts of the country.

DULUTH AMATEURS ORGANIZE

. . . Our group was just organized in October, and no doubt will be increasing in membership. Dr. Edward Campbell helps direct us in our discussions. Several in the group are now constructing their own telescopes. We meet on the first and third Saturdays of the month, at 8:00 p.m., at the Darling Observatory. You may communicate with Dr. Campbell, Duluth State Teachers College, or Mr. W. S. Telford, 126 N. 33rd Ave. E., who is secretary.

MARCELLA VON GOERTZ

NATIONAL CAPITAL AMATEURS

An old mansion, situated on Massachusetts Ave., Washington, D. C., about a mile from the U. S. Naval Observatory, is to be converted into a children's museum, a W.P.A. art center, and amateur astronomers quarters and public observatory.

The National Capital Amateur Astronomers Association plans for its new quarters an astronomical library and museum; lecture room; telescope-making workshop; observatory. Further details will be announced later.

ASTRONOMICAL ANECDOTES

FREDERIC'S BIRTHDAY, PARALLAX PROBLEMS, AND PULKOVO OBSERVATORY

IT is not too easy to find something original about the calendar each January, so I am forced to borrow an interesting item from the *Journal of Calendar Reform* for the Fourth Quarter, 1940. Under the title, "A Most Ingenious Paradox," Wade Poston, Jr., has written a critical review of calendrical matters in the Gilbert and Sullivan operetta, *The Pirates of Penzance.*

The lad Frederic, who had been apprenticed to a Pirate King until his 21st birthday, is confronted on what he thinks is his liberating birthday with the astounding information that he was born in leap year, on February 29th, and that he will not reach his 21st birthday until 1940! If we count back through 21 leap years from 1940, we arrive at the year 1852 as the year of the birth of the hero. He would have been 21 years old, however, in 1873, so this must be the time represented on the stage. But that this introduces another anachronism is evident when we find a reference to another Gilbert and Sullivan show, in the lines

> "Then I can hum a fugue of which I've heard the music's din afore,
> And whistle all the airs from that infernal non-sense *Pinafore,*"

spoken by one of the characters in *The Pirates of Penzance. Pinafore* was not produced until 1878, so the time represented by the coming of age of Frederic must have been after this date. But then, if we let it be, say, 1878 exactly, or any year after that, Frederic's 21st birthday will fall in 1944 or later. Certainly Gilbert and Sullivan forgot that 1900 was not to be a leap year; how much more badly they were confused by the calendar we can only guess.

I'm a trifle confused, too, about the distance of the sun. In the report of the meeting of the Royal Astronomical Society for June 13th of 1941, we read of a new determination of the solar parallax, from the 1931 opposition of Eros. A month later, the Astronomer Royal summarizes the work, and gives as his final value 8″.7900 with a probable error of 0″.0008, but he states that 0″.001 may be accepted as an estimate of the true probable error. These are the authoritative figures, in conventional astronomical terms, but, from these, we find the following values of the sun's distance:

Monthly Science News (London)
Aug., 1941: 93,005,000 ± 10,000 miles
Sky and Telescope
Nov., 1941: 93,003,000 ± 8,000 miles
Scientific American
Dec., 1941: 93,010,000 ± 15,000 miles

I may be wrong, but I believe the solar parallax is defined as the angle subtended, at the mean distance of the sun (that is, at a distance which is the average of the greatest and least distances), by the earth's equatorial radius. I did a little figuring for myself, and I cast my vote with Dr. Whipple's value, given in *Sky and Telescope,* despite the fact that the value first listed above was probably given by the Astronomer Royal himself. The *American Ephemeris and Nautical Almanac* value should become 93,003,132 instead of that at present listed, 92,897,416 statute miles.

But we must not forget that as by-products of the determination of the solar parallax from the Eros observations we get the ratio of the masses of the earth and moon, and another factor which includes the constants of precession and nutation. As the Astronomer Royal states, "The constant of precession is known with such accuracy that it may be said that the mass of the moon determines the constant of nutation and conversely." He goes further to say that it has been troublesome in the past for astronomers to find that the directly observed values of the moon's mass and the value from the constant of nutation do not check each other. This trouble still persists, for from the present investigation the nutation constant comes out as 9″.227 ± 0″.001, whereas the accepted figure is 9″.21; another factor, the "constant of the lunar equation," is now evaluated as 6″.439 ± 0″.0015, whereas Prof. Brouwer, in editing an unfinished paper by the late Dr. de Sitter, suggested 6″.4068 as the best value. At least it should make us somewhat wary of over-confidence concerning the physical meaning of a probable error!

To turn regrettably from progress to retrogression, we recall mention in the February, 1940, issue of The SKY, of the bombardment of the Pulkovo Observatory (November 12, 1917) by Cossack artillery loyal to the Kerensky government, attempting to dislodge the newest batch of revolutionaries who had set up their artillery within a quarter-mile of the observatory. At that time only a few stray shots struck the observatory, and no serious damage was done to any instrument. The objectives of all the instruments, including the great 30-inch refractor made by Alvan Clark in 1885, had been removed and stored in a safe place.

We can only hope that such precautions were again taken, for in *The Observatory* magazine for October, 1941, I find this item as the last paragraph in the issue: "As we go to press, news has been received of the destruction of the historic Pulkovo Observatory, in the fighting near Leningrad. The Observatory celebrated its centenary in 1939 and its loss will be felt with grief and horror by all astronomers."

R. K. M.

BOOKS AND THE SKY

THE MORNING STAR RISES

An Account of Polynesian Astronomy. MAUD WORCESTER MAKEMSON. Yale University Press, New Haven, 1941. 301 pages. $5.00.

FOR most of us the heavens are a delightful playground with a double fascination. They are a challenge to our intelligence and our search for facts, but they are also a direct inspiration in their sheer beauty and in the tales that men of long ago spun about them. In both they are distant and owe their charm largely to that cosmic remoteness from human affairs.

But the ancient Polynesians, remote as they are from us in time and space, were close to the stars. The vast empty Pacific was their universe, and it meets the sky all around. Accurate navigation over incredible thousands of miles was inherent in their way of life. The location of the stars was as vital to them as that of the myriad isles. Astronomical schools were conducted in each center of population, passing the great treasury of knowledge from generation to generation and directing all phases of the economic and industrial life of the community. But more than this, they cherished and kept bright "the magnificent conception of the Polynesian cosmos, with its tiers of heavens rising to incalculable heights, its stratified underworlds reaching down to the very foundation and root of existence, and its rich and varied pageantry outrivaling the imagery of all other primitive peoples."

The story has been gathered by Dr. Makemson, chairman of the department of astronomy at Vassar, in many years of tireless research, which included retracing the actual paths across the sea taken by the ancient explorers who first ventured eastward across the waters to people the islands. Her book contains an alphabetical list of 772 names of the Polynesian stars which have been remembered until recent years. The list itself reads like a poem. For instance: "498. Pua-tawhiwhio-Tautoru. Flower-entwined-in-Tautoru or Orion; a Maori term for the bright star Rigel, usually known as Puanga, Blossom-cluster." There is also a table identifying 41 constellations in the various Polynesian tongues and a table of the names of the months in 16 island groups. These are priceless records of scholarship.

Yet the chief interest of the book is in the practical problems which the Polynesian navigator was compelled to solve—a method "so simple and at the same time so exact that it might well be adopted today by aviators who trace the same long empty ocean routes." The method gives its name to the book—the choosing of the rising point of one particular star over the eastern horizon and steering precisely toward it day after day, or away from it on the return voyage. To make the method effective the navigators needed to know the position and brightness of several hundred stars and their relation to the calendar, the constellations, the motions of the planets, the diurnal path of the sun on any day of the year, and the motion of the moon to be used for checking on the nights when its brightness obscured all but the brightest stars. By this knowledge the widely scattered islands of the Pacific were peopled by men of one race, language, and mythology.

About half of the book is given to that mythology, the wide-spaced galleries of heaven through which the gods fly on their various errands; the Sun, giver of light and life; the Moon, enumerator of the days and months and friend of mortals; the months which are children of the Sky-father; the Great Galaxy which tends the star-children so that they do not fall to earth and become lost; the Magellanic Clouds which control the boisterous wind children and protect man from destructive hurricanes. "Everything is a part of the heavens and the earth. There is nothing of which it can be said, it is of the earth alone, or of the heavens alone." The cosmogony of the myths is complex, rich in detail and imagery, so imaginative and poetic that it puts the Mediterranean classics to shame.

Dr. Makemson's labors in collecting all this material from the ends of the earth and distilling it into one crowded book must have been colossal, but also she must have had a rich reward by living so long in a world of such rare beauty. She should have much further satisfaction from the thanks of all lovers of the lore of the stars for opening a new world to them.

GERALD WENDT
West Cornwall, Conn.

TIME AND TIMEKEEPERS

WILLIS I. MILHAM. The Macmillan Company, New York, 1941. 616 pages. $1.98.

THE title of this book identifies its contents, which also include the history, construction, care, and accuracy of clocks and watches. It was published first in 1923. The present edition is the so-called Imperial Edition, a reprint that sells for a much lower price than the original—at a price that will be welcomed by many.

Reprints of this sort often suffer in one way or another—particularly in the illustrations. You will be glad to know that after carefully comparing the illustrations with those in the original edition, I find them equally as good in the Imperial Edition, and better in many cases.

You should read the Addendum first—otherwise you may miss it, because it is inserted after the Index. There you will learn about the latest development for obtaining time by the zenith tube; and many recent books on the subject of time are brought to your attention. Although only eight pages, the Addendum is an important part of this edition.

Since this book's original publication in 1923, many advances have been made in timekeeping and timekeepers. It is therefore unfortunate that the publishers did not see fit either to provide a much larger Addendum, or to have the book revised—particularly in those chapters dealing with history, measurement, and observational methods. Mechanical difficulties probably made a revision impossible at the present time, but I hope that in the not too distant future Dr. Milham's publishers will let him revise the contents so that he can tell us more about the recent developments such as the zenith tube, and the new precision electric clocks reading directly to 1/1,000 of a second by the use of a stroboscope.

Also, in the matter of collections, the picture has changed since 1923. I make these comments only because this is such an excellent reference book, and it would seem worth while bringing it wholly up-to-date. However, these remarks are not intended to detract from the value of the book. It still is the best of its kind; and what is more to the point, you will find it not only interesting and entertaining, but easy reading as well.

R. NEWTON MAYALL
Cambridge, Mass.

NEW BOOKS RECEIVED

LIVING BIOGRAPHIES OF GREAT SCIENTISTS, *Henry Thomas and Dana Lee Thomas.* 1941, *Garden City.* 314 pp. $1.98.

These popular accounts of the lives of 20 scientists, whose names are familiar to everybody, include biographies of Copernicus, Galileo, Newton, and Einstein.

TIME AND TIMEKEEPERS, *Willis I. Milham.* 1941, *Macmillan.* 616 pp. $1.98.

To anyone interested in time and how it is kept, this reissue in an inexpensive edition of an important book will be very welcome.

YANKEE STARGAZER—The Life of Nathaniel Bowditch. *Robert Elton Berry.* 1941, *Whittlesey.* 234 pp. $2.50.

The life of the author of "the seaman's Bible" makes fascinating reading for people interested in astronomy, navigation, and the great shipping days of old Salem.

NEW WORLDS IN SCIENCE, edited by *Harold Ward.* 1941, *McBride.* 670 pp. $3.00.

An anthology of works from the pens of our great modern scientists, *New Worlds in Science* gives a coherent picture of the tremendous progress and problems of modern scientific investigation.

EDMUND HALLEY as Physical Geographer, and the Story of His Charts, *S. Chapman.* 1941, *Royal Astronomical Society.* 15 pp. and 6 plates. 2s. 6d.

A pamphlet reprinted from *Occasional Notes, No. 9,* gives material about Halley's work in a field other than astronomy. He pioneered in physical geography and in the drawing of early nautical charts.

THE OBSERVER'S BOOK ON ASTRO-NAVIGATION, Parts I and II. *Francis Chichester.* 1941, *Chemical Publishing.* 103 pp. and 83 pp. $1.25 each.

Only modern methods of navigating by the stars are described in these two compact manuals. Those already familiar with dead-reckoning methods may teach themselves air navigation from these books.

DOCTOR WOOD, *William Seabrook.* 1941, *Harcourt, Brace.* 335 pp. $3.75.

Subtitled "Modern Wizard of the Laboratory," this sparkling biography relates the fascinating life story of Robert W. Wood, an outstanding physicist and inventor.

THE OBSERVER'S HANDBOOK FOR 1942, edited by *C. A. Chant.* 1942, *Royal Astronomical Society of Canada.* 80 pp. $0.25.

Annual edition of the most usable collection of ephemeris material for the amateur observer.

ANSWERS TO DO YOU KNOW?

(*Questions on page* 8)

I. 1, d; 2, c; 3, b; 4, a; 5, a; 6, b; 7, c; 8, a; 9, b; 10, b.

II. a. 2.512 is the ratio of brightness between magnitudes.
b. 864,100 is the sun's diameter in miles.
c. 3934 is an important calcium line (the **K** line) in angstrom units.
d. 23° 27′ is the inclination of the earth's orbit to its equator, hence the distance from equator to tropic or polar circle to pole.
e. 6.55×10^{-27} is Planck's quantum of energy in erg-seconds.
f. —26.6 is the apparent magnitude of the sun.

III. 1. The mass is ⅛, the diameter ½. **(5 points)**
2. The surface gravity is ½ that on earth, or 16 ft. per sec^2. **(5 points)**
3. The minimum distance of the jump can be calculated on the assumption that the jump is made with the same initial velocity as on earth. The maximum distance can be calculated by assuming the same muscular force is used. **(5 points)**
4. Assume a man jumps 3½ feet. Part of this consists of lifting his legs, say 1½ feet, the rest raising his center of gravity 2 feet. Only the latter figure is affected by the conditions of the problem. Figures may vary, but the distinction of the two parts of the jump is necessary. **(Count 5 points for this distinction.)**
5. If a man jumps with the same velocity, his velocity will become zero after twice the interval required on earth, hence he will have jumped twice as high, or 4 feet. Adding the factor due to leg-lifting, his total minimum jump is 5½ feet. **(5 points for this or for an answer differing only because of different numerical assumptions.)**
6. On our assumptions, muscular force exerted through 1½ feet gives a velocity lost to gravity through 2 feet. The acceleration must then be 4g/3, the muscular force 7g/3. When this is exerted against half the gravitational force, the acceleration is 11g/6 and the jump is 5½ feet, plus 1½ equals a total of 7 feet.
The answer is somewhere between 5½ and 7 feet. For an answer in this range, not correctly calculated, score 10 points.

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The Milky Way
By BART J. BOK AND PRISCILLA F. BOK
96 Illus., 204 Pages; $2.50

Sky says: "The subject matter of **The Milky Way**—the structure, dimensions and composition of our galaxy—is a topic which deserves understanding and reiteration, and no one could have done a better job of it than Dr. and Mrs. Bok."

Earth, Moon and Planets
By FRED L. WHIPPLE
140 Illus., 293 Pages; $2.50

Science says: "This lucid book has a freshness which is amazing when one considers the large number of books which have been written about the solar system."

The Story of Variable Stars
By LEON CAMPBELL AND LUIGI JACCHIA
82 Illus., 226 Pages; $2.50

Sky and Telescope says: "A better popular exposition of some of the intricacies of these pulsating stars does not exist . . . . in the sections dealing with the red variables and the novae, this book really gets into its stride."

The above four books are ready for shipment. The following five are in active preparation:
Dimitroff and Baker—TELESCOPES AND ACCESSORIES; *Menzel*—OUR SUN; *Goldberg and Aller*—ATOMS, STARS AND NEBULAE; *Sterne and Schwarzschild*—INSIDE THE STARS; *Shapley*—GALAXIES.

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GLEANINGS FOR A. T. M.s

EDITED BY EARLE B. BROWN

THE GAVIOLA OR "CAUSTIC" TEST

THE test for optical surfaces developed by Dr. E. Gaviola, and described by him and Ricardo Platzeck in the **Journal** of the Optical Society of America, Vol. 29, No. 11, November, 1939, offers a very definite improvement in precision over the usual methods of measuring longitudinal or transverse zonal aberration at the Foucault knife edge. The distances to be measured are larger than in the latter case, and subject to a smaller proportionate error; furthermore, the nature of the test reduces to a considerable extent the errors of estimate introduced in the setting of the knife edge.

In the ordinary test of longitudinal aberrations, the procedure is to divide the mirror into pairs of zones symmetrical about the center. This may be done with a mask or by estimation of the shadows according to the "doughnut series" of A. W. Everest (see **A.T.M.A.**). The position of the knife edge upon the optical axis where a particular pair of zones darken evenly represents the point where the normals to those zones cross the optical axis. The displacement of the knife edge for each pair of zones is measured and the measurements tabulated. From a knowledge that the displacements for a perfect paraboloidal figure correspond to the relationship $r^2/2R$, we can determine the shape of the mirror with reference to the theoretical surface; here r is the radius of the zone—the distance of its center from the center of the mirror, and R is the radius of curvature of the central zone. R is determined by measuring a central zone along with the others, and measuring the distance from the knife-edge setting to the center of the mirror. (The focal length is one half of R.) It should be remembered that this relationship holds only when the light source and knife edge are moved together—if the knife edge alone is displaced, the relationship r^2/R must be used, the displacements being twice as great. The light source, of course, must be as near as possible to the knife-edge setting for the center zone, if it is held fixed.

This procedure is subject to the following errors:

1. Errors in measuring r on the mask or mirror.
2. Errors in estimating the evenness of the darkening. This is a prolific source of error, and results from:
   a. Personal errors of the observer.
   b. The fact that the darkening does not proceed at constant velocity, nor with the same velocity for both zones of a pair.
   c. Lack of considerable contrast at the edges of the shadows.
   d. The fact that two zones must be studied simultaneously.
3. Errors in measuring the displacement of the knife edge.
4. Errors in measuring R.

Errors of types 1, 3, and 4, are common to all methods, but are errors of linear measurement, and become proportionately smaller as the lengths to be measured become greater. They can be reduced by the use of more precise instruments—micrometer screws, and so on. Errors of the type 2a are common to all measurements of whatever kind, and can only be eliminated statistically, that is, by making many measurements and determining a mean. Errors 2b and 2c are peculiar to the test mentioned above; the first is due entirely and the second due principally to the fact that the measurement is made on the optical axis and not at the center of curvature of the zones in question, which means that the image of the light source is "out-of-focus" at the point where the measurement is being made. These two errors can be somewhat reduced by using a wire or a slit instead of a knife edge.

In the Gaviola, or "caustic" test, only one zone is measured at a time, hence the errors of type 2d are eliminated. This is a distinct advantage, since the inability of one eye to see two things clearly at the same time if they are noticeably separated is a common source of error in measurements involving simultaneous comparisons. In the ordinary Foucault test, the errors due to this cause become greater as the edge of the mirror is approached, and the zones become farther apart. By measuring displacements which are greater than in the ordinary Foucault test, the Gaviola test reduces errors of the types 1 and 3 considerably. Errors 2b and 2c are materially reduced because the measurements are made at the true centers of curvature and the shadows are consequently quite sharp; indeed, it is possible to measure, not the shadows, but the actual image itself. Thus the Gaviola test is capable of measuring variations on the surface of the mirror of the order of 1/100 of a wave length of light—about one 10-millionth of an inch. The corresponding limit for the ordinary Foucault test is probably not more than 1/10 of a wave length at its very best.

Principle of the Gaviola or "caustic" Test:

Consider the diagram: MVN is the surface of the mirror, and CVC is the sphere which is tangent to the mirror at the center. Two symmetrically-opposed zones (**d**, **d**) are to be measured. **O** is the center of the reference sphere, and **P** is the intersection of the optical axis with the normals to the mirror at points in the center of the zones **d**, **d**. **S** and **T** are the true centers of curvature of the two zones, and the knife edge drawn at **P** indicates how the light is cut off in the ordinary Foucault test. The Gaviola test consists of determining the positions **S** and **T** in rectangular coordinates centered at **O**. That is to say, the height of a perpendicular dropped from **S** to the axis is measured, and distance from **O** to this perpendicular, giving us values **B** and **A**, respectively. The same measurement is made for **T**, which should be symmetrical with **S** with respect to the axis.

Now, for any given curve, the loci of its centers of curvature can be found. This is a problem of the differential calculus, and if the curve is $y = f(x)$ the parametic equations of the locus of the centers of curvature are:

$$A = x - \frac{\frac{dy}{dx}\left\{1 + \left\{\frac{dy}{dx}\right\}^2\right\}}{\frac{d^2y}{dx^2}}, \qquad B = y + \frac{\left\{1 + \left\{\frac{dy}{dx}\right\}^2\right\}}{\frac{d^2y}{dx^2}} \tag{1}$$

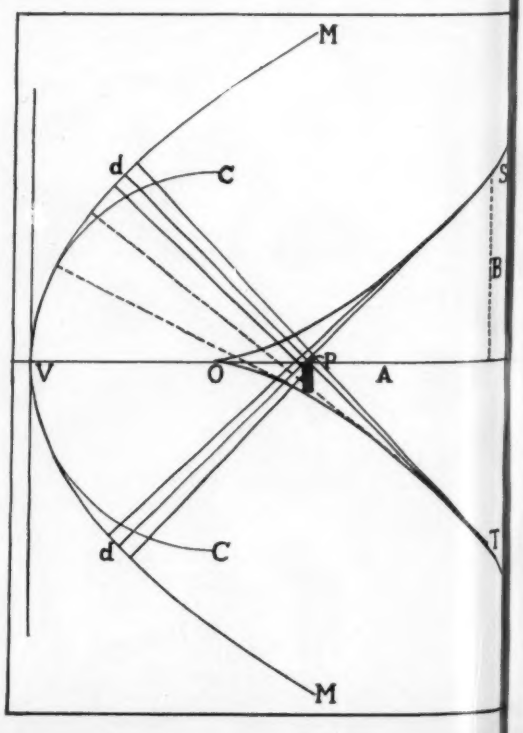
where A and B are the coordinates of the required locus in terms of the coordinates (x, y) of the curve f(x). This locus of centers of curvature is called the evolute or caustic of the curve f(x) and its development is covered in any standard text on the calculus; we need not give it here. In particular, the evolute of a parabolic curve is given by the parametric equations:

$$A = \frac{3r^2}{2R} + R \qquad B = -\frac{r^3}{R^2} \tag{2}$$

or by the equation:

$$\frac{R}{2}B^2 = \frac{4}{27}\left\{A - R\right\}^3 \tag{3}$$

where r and R are the distance of the point on the mirror from the optical axis and the radius of curvature of the center zone, respectively, and A and B are the coordinates of the points on the evolute, referred to the center of the mirror as origin. If we move the origin to the point representing the center of curvature of the center zone of the mirror, viz., the setting



of the knife edge for measuring R, our parametric equations become

$$A = \frac{3r^2}{2R} \qquad B = -\frac{r^3}{R^2} \qquad (4)$$

and give us directly the displacement of the knife edge for the various zones. **Note that the longitudinal displacement, A, is three times that of the ordinary Foucault test; therefore, the proportionate error introduced by a given inaccuracy of measurement is only one third as great.**

Simplification of the Test:

Direct measurements of the positions of the centers of curvature would involve the determination, by measurement, of both A and B. However, if the departure of the mirror to be tested from the theoretical paraboloid is not great (and it will not be on the final tests), we can predetermine the A coordinate for the theoretical paraboloid, and measure the B coordinate only (the coordinate at right angles to the optical axis). We can then tabulate the theoretical B-values and determine the deviations of our measured B's from the theoretical values. Then, the deviation of the mirror surface from the theoretical paraboloid is given by

$$h = B' \frac{d}{R} \qquad (5)$$

where B′ is the deviation of the measured B from the theoretical value, d is the width of the zone in question, and h is the departure of the mirror, over the distance d, from the theoretical paraboloid.

Of course, if we can find some other paraboloid whose average departure from the mirror is less than that of the paraboloid whose focus is R/2 (see **Sky and Telescope**, December, 1941), we would prefer to use this as a curve of reference. Some space will be devoted to this problem of "best-fit" in following articles, since the procedure also is made use of in the Hartmann test (see The SKY, January, 1941).

This article will be continued in the February SKY AND TELESCOPE, *giving a discussion of the apparatus required for the test, and the actual procedures of observation involved.*

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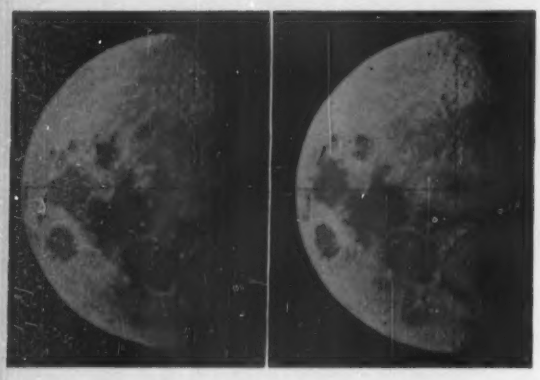
J. C. Reiss, 10 Hill Street, Newark, N. J.

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern Standard.

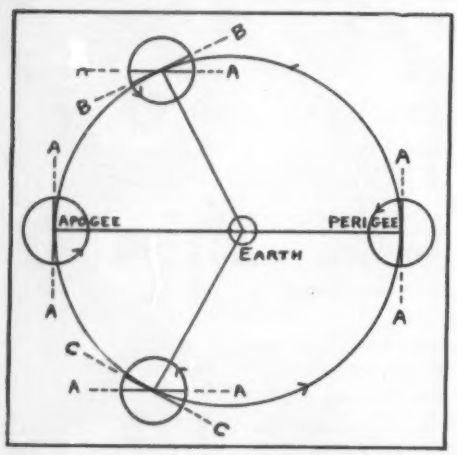
The Moon's Libration in Longitude



In these photographs from *Le Ciel* note the shift in the positions of the three craters (named in text) near the center of the moon's disk. This is the libration in longitude.

ONE of the chief factors in our being able to see more than one half of the moon's surface is the libration in longitude. It may be easily observed with binoculars; if a telescope is used, the lowest magnification available will bring the best results. This libration is an apparent rocking motion, from west to east, known as **positive**, and from east to west, **negative**. The view at the left in the illustration was taken when the positive libration was a maximum and shows a wide separation between the edge of the moon and such familiar markings as the Sea of Crises, whereas the view at the right shows the maximum negative libration. However, foreshortening makes the libration change less noticeable near the moon's limb than in the center of the disk, as the reference cross lines show.

These librations have a decided effect on the observed time of appearance of certain craters on the terminator (time when the sun rises as seen from them). When there is no libration, the crater Theophilus is in excellent position for observation when the moon is five days old, but at maximum negative libration it may be seen eight hours earlier, and at maximum positive libration, eight hours later. The craters Ptolemaus, Alphonsus, and Arzachel, are particularly affected in this manner because they are in the center of the disk.



The maximum libration in longitude occurs when the moon is halfway *in time* (not in distance) from perigee to apogee.

The cause of the libration in longitude is the eccentricity of the moon's orbit. When the moon is nearest the earth (perigee), its orbital velocity is greatest; when it is farthest (apogee), the motion is least. However, the rotation of the moon on its axis is quite regular and takes place independently of the orbital motion (except that periods of revolution and rotation are exactly equal). Therefore, when the moon is at that position halfway **in time** between perigee and apogee, the mid-point on the lunar surface has turned just 90 degrees, but not sufficiently far for it to be in line with the direction toward the earth, as it was at perigee. In reverse manner, this occurs again when at a position mid-

THE PLANETS IN JANUARY

Mercury reaches its greatest eastern elongation on January 25th, when it will be 18° 31′ from the sun. Its southerly declination, —15°, will cause it to appear close to the horizon for observers in mid-northern latitudes, but being five degrees north of the sun, it should be clearly visible for a short interval after sunset.

Venus, in Capricornus, will be a brilliant sight during the early part of the month, but will approach the sun rapidly, and disappear in its glare at the end of the month.

Earth, on January 2nd at 2 p.m., will reach perihelion (nearest the sun).

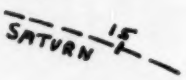
Mars, in progressive motion, will be in Pisces and Aries.

Jupiter, in Taurus, will be in retrograde motion throughout the month.

Saturn, in Taurus at the beginning of the month, will move into Aries on January 8th. Its motion will be retrograde until the 23rd.

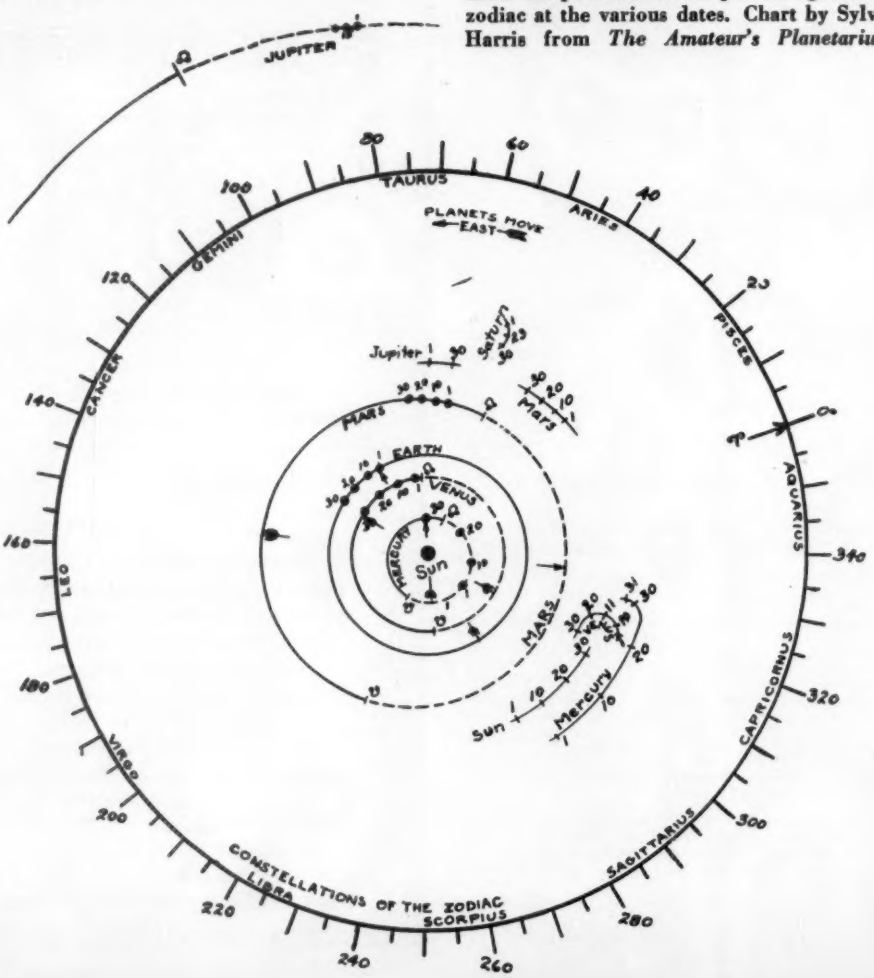
Uranus. See diagram in the November issue.

Neptune, in Virgo, is in retrograde motion throughout the month. On January 21st it will be in conjunction with and 29 minutes south of the star B.D. +2° 2509, magnitude 7.6.



In the chart below, the orbits of the planets are drawn to scale, and on the orbits are shown the heliocentric positions of the planets. Ascending and descending nodes are also marked by the usual symbols.

For convenience, *geocentric* positions are also shown. Suppose, instead of the sun, we had the earth at the center of the diagram. Then straight lines drawn from it through the short arcs just outside the Mars orbit show the positions of the planets against the zodiac at the various dates. Chart by Sylvan Harris from *The Amateur's Planetarium*.



way in time from apogee to perigee. In the first case, we see the lunar hemisphere B-B (positive libration), and in the second C-C (negative libration), whereas A-A is seen only at perigee and apogee.

In January, perigee happens on the 14th, and new moon on the 16th, so when we first are well able to see the crescent moon, say on the 19th when it is three days old, the positive libration will be within two days of maximum. If the moon is observed carefully each clear night for the next two weeks, or until two or three days after the full phase, the Sea of Crises can be plainly seen to shift toward the east for two days and then retreat until it is close to the western edge when the terminator begins to cover it. After the full phase we can watch the craters Grimaldi and Riccioli shift toward the west until February 14th, when the negative libration will be a maximum. They will then move eastward until the next perigee, four days before the February new moon.

OCCULTATIONS—JANUARY, 1942

Local station—lat. 40° 48'.6, long. 4h 55.8m west.

Date	*Mag.*	*Name*	*Immersion*	*P.**	*Emersion*	*P.**
Jan. 1	5.5	130 Tauri	5:11.1 a.m.	137°	5:51.8 a.m.	230°
26	6.4	70 Tauri	7:13.3 p.m.	114°	8:26.5 p.m.	219°
26	5.3	75 Tauri	9:28.3 p.m.	50°	10:44.0 p.m.	292°
26	4.8	264 B Tauri	10:49.7 p.m.	105°	0:04.2 a.m.	245°
27	6.5	275 B Tauri	0:41.3 a.m.	89°	1:47.0 a.m.	265°
27	1.1	Aldebaran	2:01.5 a.m.	49°	2:46.9 a.m.	306°
28	5.1	111 Tauri	1:31.9 a.m.	146°	2:10.0 a.m.	218°
28	6.4	B. D. +18° 1112	10:31.4 p.m.	92°	11:59.1 p.m.	273°
29	5.7	124 H^1 Orionis	0:59.6 a.m.	133°	1:59.0 a.m.	239°
29	6.2	110 B Geminorum	10:15.5 p.m.	105°	11:44.5 p.m.	268°
31	6.2	2 B Cancri	0:59.7 a.m.	67°	2:04.1 a.m.	322°

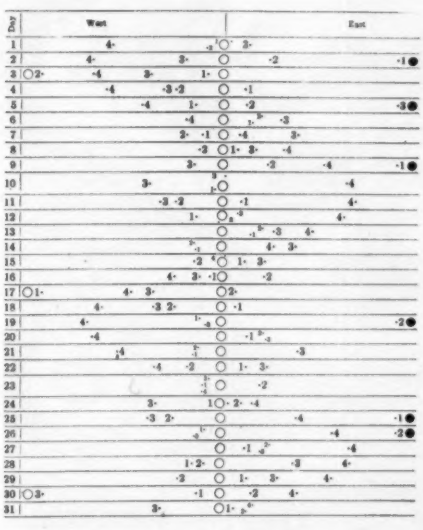
*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

Following the occultations of the stars 75 and 264 B Tauri on January 26th, the stars B. D. +15° 633, magnitude 6.6, and B. D. +15° 640, magnitude 6.7, will be occulted.

Within a few minutes of the midway point of the occultation of 75 Tauri, the star θ^1 Tauri, magnitude 4.0, will be in conjunction with the moon. This will occur at 10:09.3 p.m., at which time the star will be south of the moon's edge by a distance equal to five per cent of the moon's diameter as seen from our local station.

JUPITER'S SATELLITES

Jupiter's four bright moons have these positions at 11:15 p.m. E.S.T., on the day preceding the date shown below. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris.**



During the evening of January 12th the four moons will be on the east side of Jupiter and in numerical order, I being nearest the primary.

On January 18th, from 6:44 p.m. to 8:04 p.m., the four moons will be on the west side. At the beginning of this interval they will be in numerical order, I nearest the primary. This order will change rapidly due to the motions of I and II being in opposite directions; there will be an occultation of II at 8:04 .

During the evening of January 26th, the four moons will be on the east side, and in numerical order after midnight, following the conjunction of II and III.

Very early in the evening of January 15th, and after 9:50 p.m. on January 22nd, the shadow of III will be in transit across the face of the planet. This moon casts the largest and apparently the darkest shadow, which may be easily seen in small telescopes.

PHASES OF THE MOON

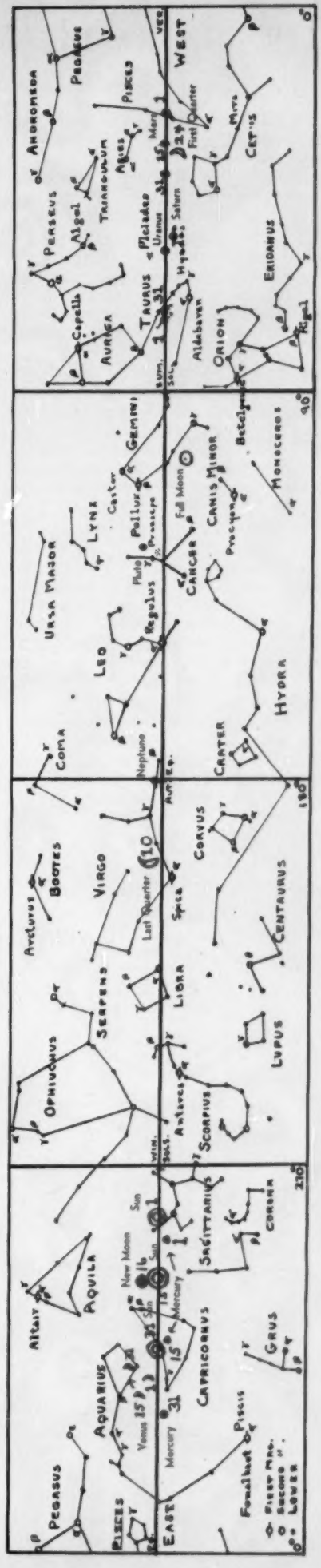
Full moon	Jan. 2, 10:42 a.m.
Last quarter	Jan. 10, 1:05 a.m.
New moon	Jan. 16, 4:32 p.m.
First quarter	Jan. 24, 1:35 a.m.

MINIMA OF ALGOL

January 1, 8:55 p.m.; 4, 5:45 p.m.; 16, 5:02 a.m.; 19, 1:51 a.m.; 21, 10:40 p.m.; 24, 7:29 p.m.

THE ECLIPTIC CHART

at the right is drawn with the ecliptic as its central line, instead of the celestial equator. Perpendicular to this are lines marking celestial longitude. The positions of the sun, moon, and inner planets are shown for the beginning, middle, and end of the month. The outer planets do not change materially from the positions shown during that time. Computations for plotting the planets are by Sidney Scheuer. On the next page is the star chart for this month.



THE APPARENT POSITIONS IN THE HEAVENS OF THE SUN, MOON, AND PLANETS.

THE STARRY HEAVENS IN JANUARY

By Leland S. Copeland

NIGHT'S jewels are seen at their best in winter.

Seven handsome stars appear high in the January sky—Capella, Aldebaran, Pollux, Betelgeuse, Rigel, Sirius, and Procyon. At 9:00 p.m., Deneb is about to set, while low in the east sparkles Regulus, promise of spring. Three planets this year support the bright shining of the stars—Jupiter retrograding in Taurus, Saturn back-swinging in Aries, and Mars receding from the earth and speeding along in Cetus.

To dwellers in the southern United States, January brings back Canopus, next in splendor to Sirius. Just as nature-lovers in Argentina and Australia delight in the Southern Cross, so sky watchers of our South and Southwest look for Canopus as it draws a small arc across the southern sky.

At 9:00 o'clock in the evening in mid-January, Aldebaran, red eye of Taurus, and the V-shaped Hyades, forming the animal's face, "hold" the top of heaven. The silver-tangled Pleiades rest on a shoulder of the Bull. One of the extremely long horns ends in El Nath (β Tauri), which is also a part of the pentagon of Auriga, with Capella and two kids (three fainter stars) at the top.

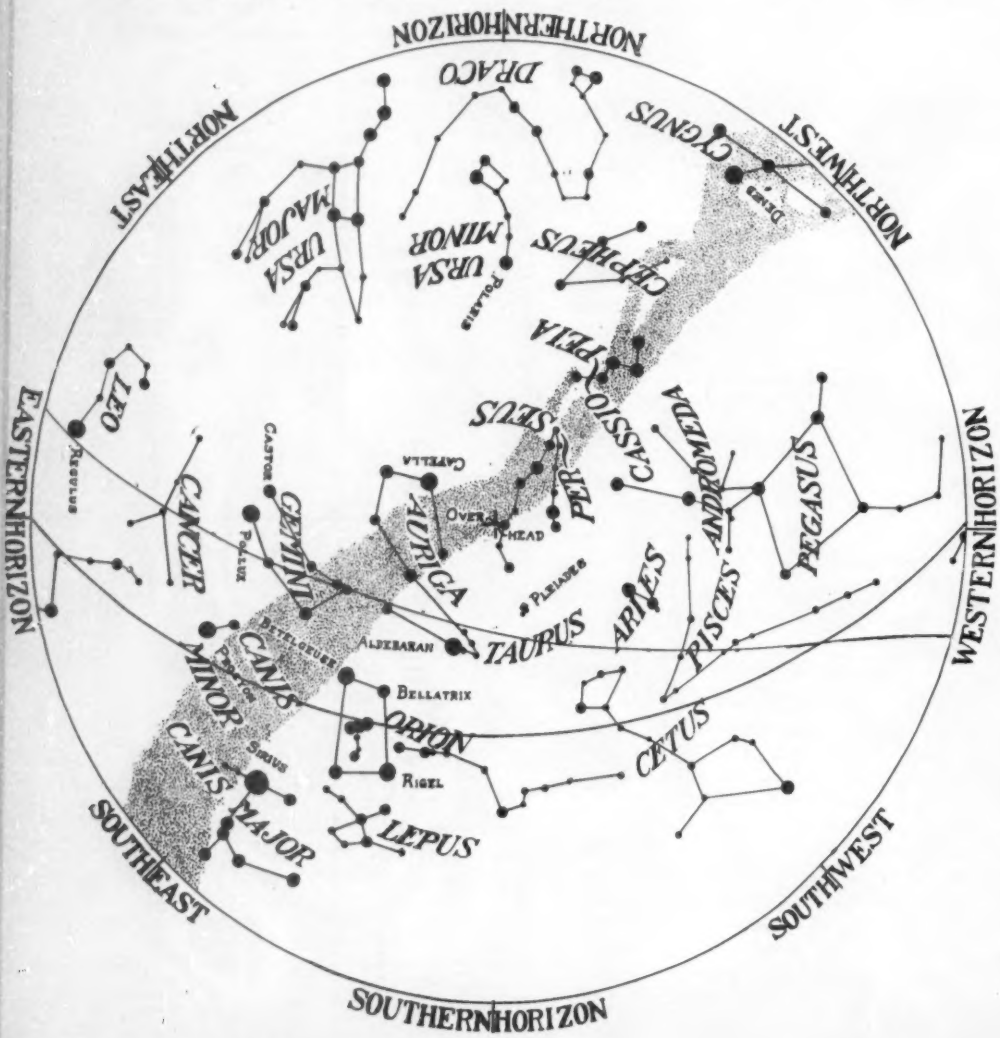
Below Taurus, and to the east, flames Orion, including seven notable stars. A curving line of faint stars flaunts the lion-skin in the Bull's face, and other dim stars form a menacing club. Now the battle of the ages is about to enter a new phase. Through late autumn the giant hunter fought an uphill contest, but soon he will be above the beast and begin to drive him down the western hill.

In the north, west of Auriga, Perseus reclines. One hand holds the snaky Gorgon's head, famous for its "demon star," Algol, and one leg extends in a graceful curve toward the Pleiades. West of him Cassiopeia and Andromeda slope toward the horizon, with Andromeda descending head foremost.

Castor and Pollux, shining in the heads of the Twins, are east of Auriga and Taurus. Here were found two planets—Uranus in the 18th century and Pluto in the 20th. South of Gemini we spy Procyon, which with several faint stars forms wee Canis Minor. The Lesser Dog is riding on the back of Monoceros, an eye-teasing formation.

Below this faint region of the Unicorn is its brilliant contrast, the Greater Dog, with bright Sirius and four other choice stars. And farther east and south are parts of Jason's ship, Argo.

Hour by hour the ancient procession rolls westward for those who linger to watch.



ORION, GLORY OF WINTER

ORION is the richest constellation known to the unaided eye. Among amateurs it shares honors with Sagittarius, which excels in objects for common telescopes.

Aratus, poet of 275 B.C., remarked, "Let no one imagine he can see stars more fair," and Flammarion, French astronomer, called Orion "the California of the sky." Human beings through the centuries, since man first looked upward, have admired its beauty. It is a tie that unites us with other ages, from the bronze era to the far future.

Three times Orion is mentioned in the **Bible,** and four times in Homer. In **The Iliad,** Achilles' shield pictures Orion and the Bear. And **The Odyssey** includes a placid starry night: "So Ulysses sat and deftly guided his craft, nor did sleep fall on his eyelids, as he viewed the Pleiades and Boötes, and the Bear, which watches over Orion." The time must have been autumn or early winter.

Orion, the Pleiades, and Ursa Major have been favorite stellar groups in all ages, and are those best known today, both by authors and laymen.

In "The Occultation of Orion" Longfellow beautifully and musically describes "the great giant Algebar."

Modern novelists also know the huge hunter. D. H. Lawrence in **Sons and Lovers** writes: "They had glimpses of their own constellation, Orion, towards the west. His jewels glimmered for a moment, his dog ran low, struggling through the spume of cloud."

Probably Orion originated in Babylonia, and its design was carried to Phoenicia and Palestine, and later, to Greece. In the **Bible** it is called Kesil, the fool, because the Jews thought it represented Merodach, a Babylonian god.

The Jewish term, fool, was appropriate, because Orion was an unwise lover. His first flame was Merope, princess of Chios, Aegean isle. When the king delayed their marriage, Orion tried to kidnap the girl, but her father put out the giant's eyes. Led to the rising sun by young Kedalion, Orion's sight was restored.

Any one who studies the constellation knows that Orion had a small head. When he pursued the daughters of Atlas, Jupiter placed them in the sky as the Pleiades.

He was next charmed by Diana. High society turned his head, so that he boasted he could kill anything. Such arrogance aroused the gods, who sent a scorpion to sting him to death. Both Scorpius and Orion are now in the sky, but by Diana's craft they are at opposite sides, so that (in mid-northern latitudes) Scorpius sets just before Orion rises.

THE STARS FOR JANUARY

as seen from mid-northern latitudes at 9 p.m., January 7th; 8 p.m., January 23rd. Magnitudes of the stars are indicated by the sizes of the disks marking the stars, and the names of some of the brighter stars appear. The ecliptic and the equator are shown, the latter touching the horizon at the east and west points. See chart on the Observer's Page for the positions of the sun, moon, and planets this month.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*Hour*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	BOND AST. CLUB	1st Thu.	8:15 p.m.	Oct.-June	Harvard Observatory	Homer D. Ricker, Harvard Observatory
"	A.T.M.S OF BOSTON	2nd Thu.	8:15 p.m.	Sept.-June	Harvard Observatory	E. R. Lacy, Harvard Observatory
BROOKLYN, N. Y.	ASTR. DEPT., B'KLYN INST.	Round Table 3rd Thu.	8:00 p.m.	Oct.-April	Brooklyn Institute	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.S & OBSERVERS	1st & 3rd Fri.	8:00 p.m.	Oct.-June	Museum of Science	J. J. Davis, Museum of Science
CHATTANOOGA	BARNARD A. S.	4th Fri.	7:30 p.m.	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	BURNHAM A. S.	2nd & 4th Tue.	8:00 p.m.	Sept.-June	Congress Hotel	Wm. Callum, 1435 Winona Ave.
CLEVELAND	CLEVELAND A. S.	Fri.	8:00 p.m.	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH, FLA.	D. B. STARGAZERS	Alt. Mon.	8:00 p.m.	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	DETROIT A. S	2nd Sun.	3:00 p.m.	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	NORTHWEST A. A. S.	1st & 3rd Tue.	8:00 p.m.	Sept.-June	Redford High Sch.	L. H. Sprinkle, R. 2, Farmington
DULUTH, MINN.	DULUTH AST. CLUB	1st & 3rd Sat.	8:00 p.m.	All year	Darling Observatory	W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	TEX. OBSERVERS	No reg. meetings	.....			Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	ALA. A. A.	1st Thu.	7:30 p.m.	All year	Ala. Power Auditorium	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	INDIANA A. A.	1st Sun.	2:00 p.m.	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
LOS ANGELES	L. A. A. S.	2nd Thu.	8:15 p.m.	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'VILLE A. S.	3rd Tue.	8:00 p.m.	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	MAD. A. S.	2nd Wed.	8:00 p.m.	All year	Washburn Observatory	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	MILW. A. S.	1st Thu.	8:00 p.m.	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	POP. AST. CLUB	2nd Tue.	7:30 p.m.	All year	Sky Ridge Observatory	Carl H. Gamble, Route 1
NEW HAVEN	NEW HAVEN A. A. S.	1st Sat.	8:00 p.m.	Sept.-June	Yale Observatory	F. R. Burnham, 820 Townsend Ave., 4-2618
NEW YORK	A. A. A.	1st & 3rd Wed.	8:15 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
" "	JUNIOR AST. CLUB	Alt. Sat.	8:00 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORWALK, CONN.	NORWALK AST. SOC.	Last Fri.	8:00 p.m.	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	EASTBAY A. A.	1st Sat.	8:00 p.m.	Sept.-June	Chabot Observatory	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. OF F.I.	3rd Fri.	8:00 p.m.	All year	The Franklin Institute	Edwin F. Bailey, *Rit.* 3050
"	RITTENHOUSE A. S.	2nd Fri.	8:00 p.m.	Oct.-May	The Franklin Institute	A. C. Schock, *Rit.* 3050
PITTSBURGH	A. A. A. OF P'BURGH	2nd Fri.	8:00 p.m.	Sept.-June	Buhl Planetarium	F. M. Garland, 1006 Davis Ave., N.S.
PORTLAND, ME.	A. S. OF MAINE	2nd Fri.	8:00 p.m.	All year	Private Homes	H. M. Harris, 27 Victory Ave., S. Portland
PROVIDENCE, R. I.	SKYSCRAPERS	1st Wed.	8:00 p.m.	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
READING, PA.	READING-BERKS A. C.	2nd Thu.	8:00 p.m.	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A. S. OF NEV.	4th Wed.	.....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	ROCH. AST. CLUB	Alt. Fri.	8:00 p.m.	Oct.-May	Eastman Bldg., Univ. of Rochester	P. W. Stevens, 1179 Lake Ave., *Glenwood* 5233-*R*
SAN ANTONIO	SAN ANT. A. A.	3rd Mon.	8:00 p.m.	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'TADY AST. CLUB	3rd Mon.	8:00 p.m.	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	ST. JOSEPH VAL. AST.	Last Tue.	8:00 p.m.	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
TACOMA, WASH.	TACOMA A. A.	1st Mon.	.....	All year	Coll. of Puget Sound	Geo. Croston, *Gar.* 4124
WASHINGTON, D. C.	NAT'L. CAP. A. A. A.	1st Sat.	8:00 p.m.	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J
WICHITA, KANS.	WICHITA A. S.	2nd Tue.	8:00 p.m.	All year	East High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148

Sky and Telescope is official publication of many of these societies.

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PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *January*, BOMBERS BY STARLIGHT.

The Buhl Planetarium, beginning January 7th, brings back by popular demand its vital and timely story of national defense—defense especially in the air. First, with the Planetarium's hemispherical dome turned into a huge curved map, we see America's true place on this rapidly shrinking planet today and the principal problems in the defense of democracy. Then, with the dome magically changing into the nighttime heavens, the important role of the stars in guiding the aviator over land and sea is presented graphically to visitors. Finally, the airplane itself enters the Planetarium sky, and there follows by means of specially constructed gadgets the realistic bombing of a great city, exemplifying the coordination of all resources essential to successful defense in modern all-out war. Giant bombers drone overhead in mass formation, swift fighter planes engage in combat, searchlights sweep the sky, anti-aircraft guns spring into action as the invader releases his hordes of parachute troops. Unforgettably is shown the need of split-second cooperation between all defense units in today's defense of freedom.

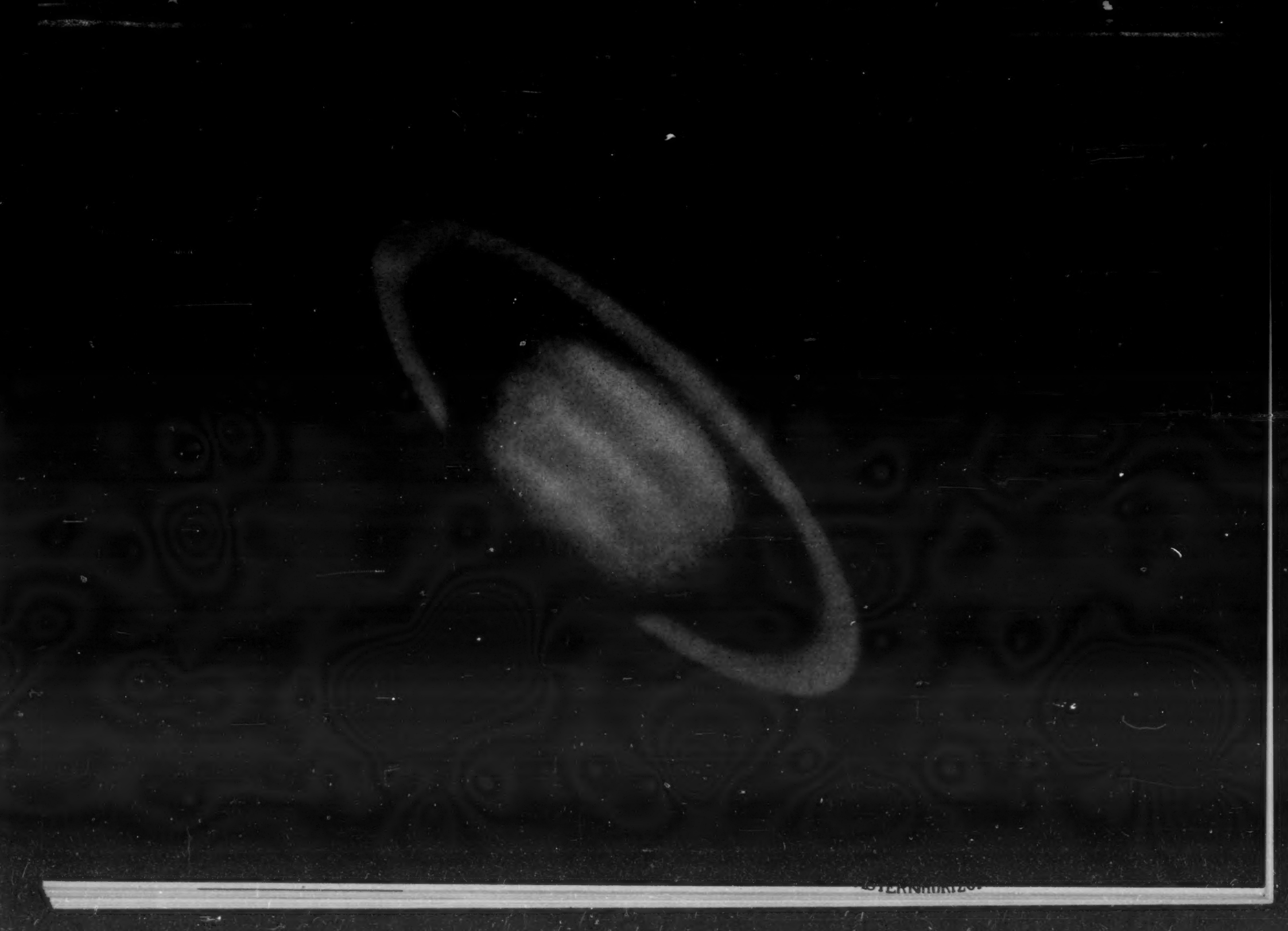
★ SCHEDULE BUHL PLANETARIUM

Mondays through Fridays ..... 3, 8, and 9 p.m.
Saturdays ..... 2, 3, 8, and 9 p.m.
Sundays and Holidays ..... 3, 4, 8, and 9 p.m.

★ STAFF—*Director*, Arthur L. Draper; *Lecturers*, O. P. Keeney, Nicholas E. Wagman; *Business Manager*, Frank S. McGary; *Public Relations*, John J. Grove; *Curator of Exhibits*, Fitz-Hugh Marshall, Jr.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ..... 2, 3:30, and 8:30 p.m.
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays—Mutual Network Broadcast—Coast-to-Coast .... 9:30-10:00 a.m.
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Assistant Curators*, Marian Lockwood, Robert R. Coles.

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